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ASPECTS OF THE ECOLOGY OF KEA, *Nestor notabilis* (GOULD), AT ARTHUR'S PASS AND CRAIGIEBURN VALLEY

A thesis
submitted in partial fulfilment
of the requirements for the Degree
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by
R. Brejaart

Lincoln University

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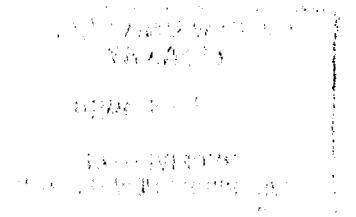

Abstract of a thesis submitted in partial fulfilment of the requirements for the Degree of Master of Applied Science

Aspects of the ecology of kea, *Nestor notabilis* (Gould)
at Arthur's Pass and Craigieburn Valley
by R. Brejaart

Where people use the habitat of kea (*Nestor notabilis* (Gould)), problems related to kea activity often occur. Such problems are the result of the inquisitive nature of kea and are thought to be related to the availability of anthropogenic foods. Kea were observed at two sites, Arthur's Pass Village and Craigieburn Valley Skifield. The two sites were chosen because they are in close proximity to one another, accessible all year round and problems with kea were known to have occurred at the sites. The objective of this study was to contribute guidelines for a kea-friendly habitat management.

Kea were banded with metal bands and individual colour bands to allow for easy identification of individuals. Monthly visits were made to both study sites. Observations were made on activities of kea, on seasonal and diurnal changes in numbers of kea, and on movements of kea. There were marked differences between the sites, in the average number of kea seen in each month. There was a strong correlation between the availability of anthropogenic foods and numbers of kea present at Arthur's Pass. It is suggested that anthropogenic foods attract kea to Arthur's Pass.

Kea at Arthur's Pass were mostly adult males. Family groups, comprised of kea of all ages and both sexes were observed throughout the year at Craigieburn. At Craigieburn age-related differences in manipulative activities were evident.

Activities did not differ quantitatively between the sites, but the focus of foraging and manipulative activities differed greatly. Kea at Craigieburn fed mainly on natural foods, but this was a reflection of availability. Kea at Arthur's Pass ate almost exclusively anthropogenic foods. Likewise, manipulative behaviours were characterised by a focus on natural resources at Craigieburn, but at Arthur's Pass kea manipulate mostly human made objects.

Damage to human made objects was limited at Craigieburn, but evident at Arthur's Pass. In addition, at Arthur's Pass kea suffered injury and death as a result of human activity.

Key words: kea, *Nestor notabilis*, Arthur's Pass, Craigieburn, habitat management, manipulative-play behaviour, foraging behaviour, movement patterns.

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CHAPTER 1

INTRODUCTION

1.1 Status and distribution of the kea

The kea (*Nestor notabilis* Gould) is a large parrot (650 - 1100 g), endemic to the montane and alpine areas of the South Island of New Zealand. By the late 1860s, the kea had earned a reputation as a sheep killer, and was regarded as a pest (Benham, 1907; Marriner, 1908). The extent to which this reputation was warranted has not yet been satisfactorily resolved, but for nearly 100 years a bounty scheme was in place resulting in the destruction of an estimated 150,000 kea (Anderson, 1986).

Kea were granted partial protection under the Wildlife Act (1953), which afforded them protection in National Parks, Forest Parks and reserves. Since 1986, the kea has been a fully protected species, but conflicts still occur where humans enter their mountain domain (Grant, 1993). Anderson (1986) suggested that the total wild population was 1000-5000, but this estimate was little more than a guess. Wilson & Brejaart (1992) cautioned that the tendency for kea to congregate at sites of human activity may give a misleading impression of their abundance, a notion supported by Bond & Diamond (1992). Presently, kea are not considered endangered, but the species has been described as regionally threatened (Bell, 1986), threatened (Robertson, in Grant, 1993), and the Department of Conservation (DoC) has categorised kea as a second priority threatened species (Molloy & Davis, 1992).

Kea are omnivorous, but their diet is thought to be predominantly vegetarian (Brejaart, 1988). Campbell (1976) suggested that introduced browsing mammals potentially compete with kea for food, especially when present in large numbers. Some plant species eaten by kea are also known foods of Himalayan thar (*Hemitragus jemlahicus*) and chamois (*Rupicapra rupicapra*) (Anon., 1993), the extent of any overlap has not

been established. The impact habitat modification has had on kea is unknown. Kea display a preference for forested habitats (Jackson, 1960; Wilson, 1990a). Since European settlement, large areas of montane forest have been cleared, primarily for agriculture. It is possible that this process of forest clearance has resulted in the loss of primary kea habitat. If so, the present day distribution and habitat use patterns of kea could be a result of this habitat destruction and modification. Introduced predators such as stoats (*Mustela erminea*) are known to prey on the kea's only conspecific species, the kaka (*Nestor meridionalis*) (P. Wilson, pers. comm. 1994), but it is not known if and how predators affect kea. Poaching of kea for the illegal wildlife trade has occurred in recent years (Hutching, 1990), but the extent to which this happens and the impact poaching has on the kea population are not known.

While popularly labelled an 'alpine parrot', kea are most commonly found at altitudes between 600 and 1700 metres with most activity occurring either side of the timber line (Jackson, 1960; Clarke, 1970; Wilson, 1990a). To the west of the Main Divide kea may be encountered at sea level (Jackson, 1972; K-J. Wilson, pers. comm.). Kea occur in all South Island mountain ranges. They can be found right along the west side of the Main Divide. To the east Kea occur in the Kaikoura, Puketeraki and Barrier Ranges (Campbell, 1976; Bull, Gaze & Robinson, 1985) (Fig. 1). Occasionally, kea are found outside this range (Robertson & Dennison, 1979). Kea observed in the Port Hills, Canterbury, in 1987 (K-J Wilson, pers.comm. 1994) and in the Tararua Range in the North Island (Cunningham, 1974) are believed to have been escapees from captivity. Based on fossil evidence, Holdaway & Worthy (1993) suggested that a resident population of kea in the North Island during the Otiran (20,000 - 18,000 years Before Present) is possible.

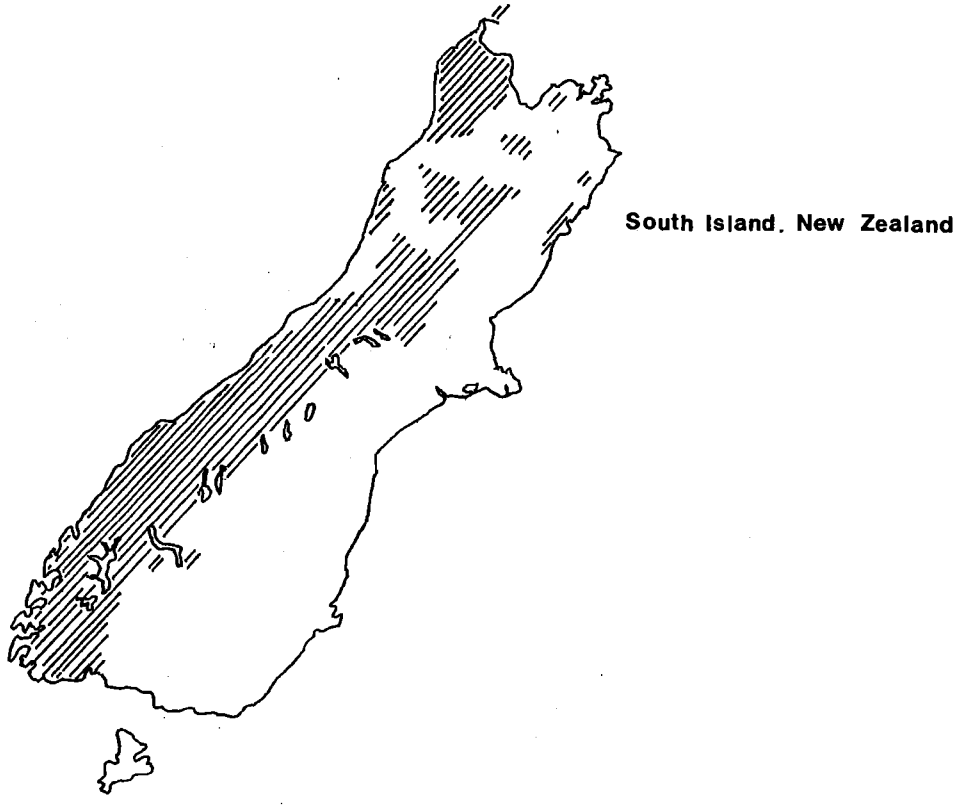


Figure 1. Distribution of kea (after Bull *et al.*, 1985)

1.2 Research to date

Wilson and Brejaart (1992) reviewed published and unpublished kea research since 1950. The following is a brief summary of that review.

Most of the early literature on kea is anecdotal and concerns the controversy surrounding kea and sheep (e.g., Benham, 1907; Marriner, 1908; Myers, 1924; Jackson, 1962a). Jackson (1960, 1963, 1969) studied movements, breeding biology, diet and mortality of kea from 1956 to the late 1960s. Interest in the biology and ecology of kea has increased gradually since then. Short term studies on population movements and food and on feeding habits of kea in their natural environment were

carried out by Clarke (1970) and Campbell (1976) respectively. A study on diet of the kea was carried out by Brejaart (1988). Up to 1986 most studies on the ethology and breeding of kea were carried out in captivity (Schmidt, 1971; Keller, 1972, 1975, 1976; Mallet, 1973; Zeigler, 1975; Potts, 1976, 1977; Kubat, 1990). In 1986, Wilson (1990a,b) began research on ecology of kea in their natural environment. This study focussed on breeding biology, movements of and habitat use by kea. Studies on the ethology of kea (Diamond & Bond, 1991) and on population dynamics of kea (Bond & Diamond, 1992) were carried out between 1988 and 1991. Currently research on kea ecology and interactions with humans and sheep is being carried out by Graeme Elliott and DoC staff in the Nelson region. While there is plenty of anecdotal material on kea at human occupied sites, little systematic research has been done.

1.3 Kea at human occupied sites

Much kea habitat falls within National Parks. There are, however, some villages and small towns and a number of localities that are occupied seasonally or infrequently by people (ski fields, tramping huts and camping grounds) within kea habitat. Kea frequent these sites and it is generally assumed they are attracted by the availability of high quality, relatively easily obtained anthropogenic foods, either from rubbish bins, dumps or deliberate handouts (Clarke, 1970; Grant, 1993; Harding, 1988; Jackson, 1960, 1969). Clarke (1970) suggested that kea also seemed to be attracted by human activity. While those people who live, work and recreate in kea habitats get much pleasure from the birds, conflicts between kea and people inevitably occur. Kea activity at human occupied sites often results in damage to human property, vehicles and dwellings, and kea may suffer injury or death, as a result of their inquisitive behaviour (Jackson, 1969; Grant, 1993).

Before 1986, attempts to reduce human-kea conflicts consisted mainly of signs warning park-users of the "destructive nature" of kea. Since 1989, a publicity

campaign has been in force, aimed at discouraging people from feeding kea. The objective of the campaign is to increase public awareness of the consequences of habituating kea to food handouts. The Department of Conservation distributes pamphlets at human occupied sites within kea habitat, explaining the basics of kea ecology and human-kea conflicts. In 1989, permanent signs were erected, dissuading visitors from feeding kea. This education programme was launched in the Canterbury region in 1989. This publicity and education campaign has since been included in the Wild Kea Management Statement (Grant, 1993), which was prepared in consultation with all South Island DoC Conservancies.

It is well established that anthropogenic foods can have a profound effect on the wildlife that use them. Garbage dumps have been adopted by a variety of mammals and birds as dependable, year round sources of food. For several species of mammal, the availability of anthropogenic food seriously compromises their natural ecology. For example, baboons (*Papio* spp.) feeding on foodscraps at garbage dumps matured faster and produced more offspring and had higher cholesterol levels than those baboons feeding on natural foods (Anon., 1990). Black bears (*Ursus americanus*) that fed on anthropogenic foods were larger and had higher reproductive rates (Graber, 1985). In addition, availability of anthropogenic foods increased the carrying capacity of the bears' habitat, and led to changes in both the diurnal rhythm and the altitudinal range of the bears (Graber, 1985). Ford (1989) described population explosions of the galah (*Eolophus roseicapillus*) following agricultural developments in Australia. Dramatic population increases in several species of gulls (*Larus* spp.) in the Northern Hemispere have been attributed to rubbish dumps and availability of anthropogenic foods (Burger & Gochfeld, 1990). While the effects of anthropogenic foods on kea are as yet unknown, dead kea have been found at rubbish dumps where they feed (DoC, unpublished data).

Two aims of the Wild Kea Management Statement are "to avoid providing kea with supplementary food (intentionally or unintentionally) and to discourage them from congregating in areas of human use, and to identify all sites in kea habitat which may affect kea detrimentally" (Grant, 1993, pg 10 & 12).

My study was designed to provide information on the role of two human occupied sites in the ecology of kea. My aim was to contribute guidelines for kea-friendly habitat management in order to reduce both the adverse impacts of people on kea and of kea on people at these sites. The sites chosen for this study were Arthur's Pass Village, and Craigieburn Valley Skifield. At both sites kea related problems had occurred and, at Arthur's Pass kea were known to suffer injury or death as a result of human activity (DoC, unpublished data; Jackson, 1969).

The specific objectives of the research were to investigate:

1) seasonal and diurnal changes in attendance of kea at the study areas (3.3.1);
2) the age and sex composition of groups of kea using the sites (3.3.2);
3) the relationship between numbers of kea at the sites and their potential attractions for kea (3.3.3);
4) movements of banded kea within and between the sites (3.3.4);
5) the activities of kea at the sites with an emphasis on foraging and manipulative activities (4.3.3).

From these observations I identified hazards for and damage by kea and suggested means of reducing these where the distributions of kea and people overlap (5.2 and 5.3).

CHAPTER 2

STUDY SITES and METHODS

2.1 Study sites

Two study sites were used during this study: Arthur's Pass Village, which is permanently inhabited by people, and Craigieburn Valley Skifield where people are present from June to October in most years (Fig. 2). The sites are 20 km apart and are accessible year round. At both sites, damage to property and equipment as well as injury to and death of kea has occurred (DoC, unpublished data, Jackson, 1960).

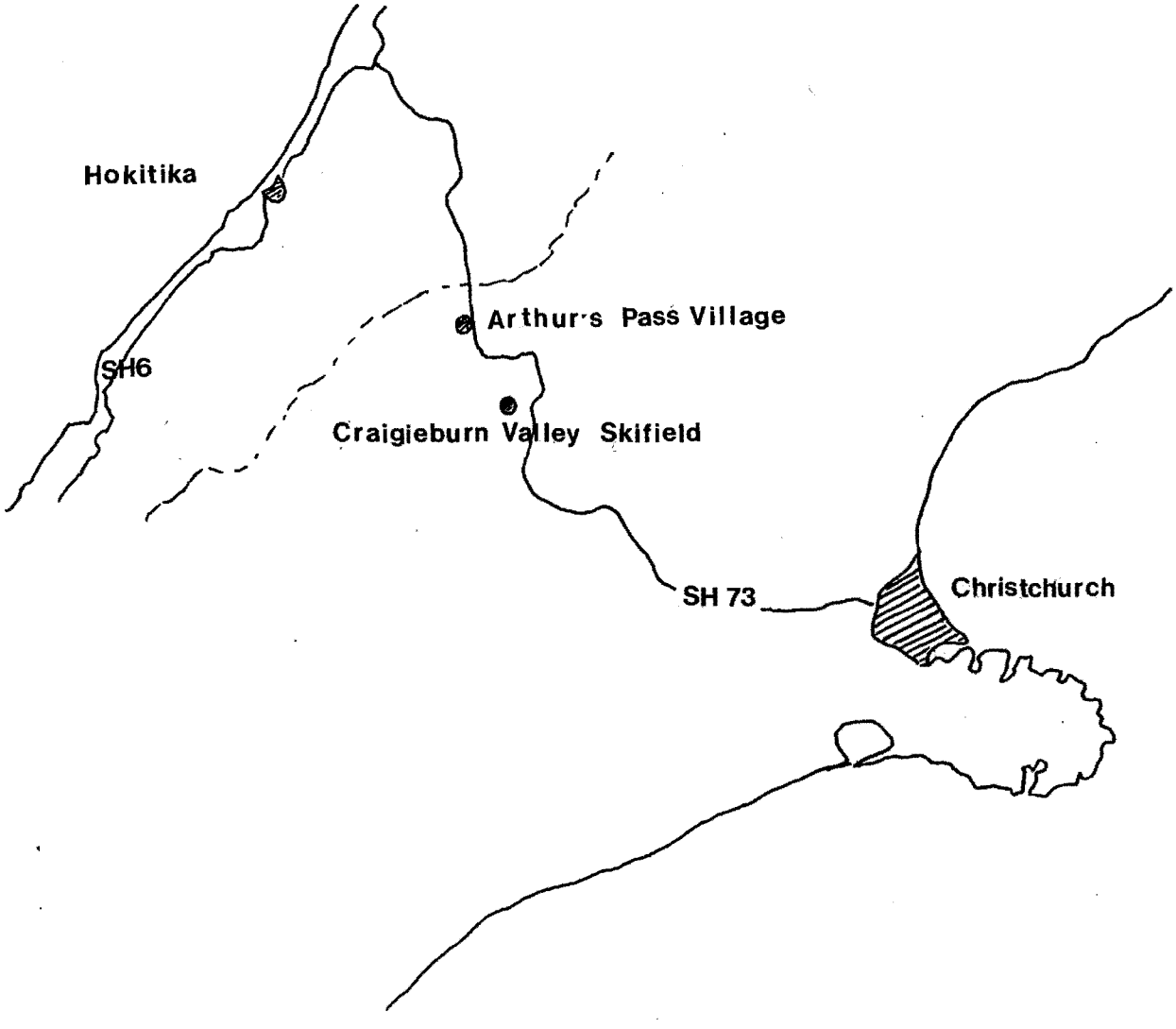


Figure. 2 Locality of the two study sites

2.1.1 Arthur's Pass Village

2.1.1.1 Location, climate and use

Location

Arthur's Pass Village (42°33'S and 171°57'E) is an alpine settlement, situated on river terraces at an elevation of 737 m, in the Bealey Valley, on State Highway 73 (Steven, 1975) (Plate 1). It lies approximately 150 km west of Christchurch and 8 km east of the Main Divide. The Bealey Valley is orientated NNW - SSE and at the village is about 300 m wide (Steven, 1975). The valley is a typical glacial valley, with steep sides and truncated spurs. On either side of the valley, the mountains rise to 1700 and 1800 m. Although situated in Arthur's Pass National Park, the village is under the administrative responsibility of the Selwyn District Council.

Plate 1. Arthur's Pass Village (*photo Kerry-Jayne Wilson*)

Climate

Arthur's Pass Village has a typically wet montane - alpine climate. Predominant winds are north-west to west. The north-west airflows are moisture laden and bring

moderate to high intensity rainfalls to the Arthur's Pass Village (de Lisle, 1969; Law, 1980). Annual precipitation in the village exceeds 4000 mm (Burrows, 1977). Snow may fall at any time of the year, but summer snowfalls are infrequent and generally confined to areas above 2000 m. The heaviest snowfalls occur from June to September. Some permanent snow and ice occurs on the higher peaks at ± 2,300 m. High diurnal and seasonal temperature fluctuations are a feature of the climate. Mean monthly temperatures are 13°C in January and 2°C in July.

Human use

Arthur's Pass Village began as a service township when a coach road over Arthur's Pass was built in the 1860s and grew larger when the railway was put through in 1923 (Anon., 1986). Currently, it still functions as a service town for road and rail, has private dwellings and accommodation for Department of Conservation staff. At the time of this study the village had a permanent population of approximately 200, but the number of people present fluctuates greatly. Human occupation of the area is greatest in summer, when visitor numbers are highest.

2.1.1.2 Vegetation

Forest zone

A monoculture of mountain beech (*Nothofagus solandri* var. *cliffortioides**) covers the steep valley slopes up to the timber line between 1200 m and 1400 m. The understorey is sparse, but includes some koromiko (*Hebe salicifolia*), tree daisies (*Olearia* spp.*) mountain ribbonwood (*Hoheria glabrata*) and a variety of ferns, which are most abundant along the stream sides (Burrows, 1977).

Plant species marked with * are known to be eaten by kea (Brejaart, 1988; Brejaart & Wilson in prep.).

Subalpine shrub zone

Above the timber line subalpine shrub communities appear. They are predominantly a mosaic of turpentine scrub (*Dracophyllum* sp.*), tree-daisies (*Olearia* spp.), hebes (*Hebe* spp.*), coprosmas (*Coprosma* spp.*), snow berry (*Gaultheria* spp.*) and snow totara (*Podocarpus nivalis**) (Burrows, 1977; Law, 1980).

Alpine tussock zone and fell fields

With increasing altitude (at about 1600 m), the shrubs give way to alpine herbfields and tussock grasslands. The species richness in these altitudinal zones varies according to substrate and precipitation. Snow tussocks (*Chionochloa* spp.*) and mountain daisies (*Celmisia* spp.*) are often dominant on the drier slopes. In the wetter places and along stream edges, soft herb communities prevail. Buttercups (*Ranunculus* spp.*), gentians (*Gentiana* spp.*) and eyebright (*Euphrasia* spp.*) are the more conspicuous members of these communities. The ridges and peaks are sparsely vegetated. Cushion forming plants and hardy rock plants grow on the exposed screes and rock outcrops (Burrows, 1977; Fisher, 1969).

Village

The village occupies a narrow belt (300 m wide, 1.8 km long) along the road on the valley floor. Here, native and naturalised flora mix along the roadside and in gardens. A variety of hebes*, coprosmas*, mountain ribbonwood and flax (*Phormium* sp.*) grow alongside raspberry (*Rubus idaeus*) canes, naturalised grasses and herbs. On the riverbed gravel coprosmas, mosses, mat-daisies (*Raoulia* spp.) and willowherb (*Epilobium* spp.) occur. Steep slopes covered in mountain beech rise above the village.

2.1.2 Craigieburn Valley Skifield

2.1.2.1 Location, Climate and Use

Location

The Craigieburn Range lies 20 km east of the Main Divide. The range stretches for about 26 km in a NE - SW direction. The terrain is characterised by slopes of between 29 and 40 degrees, less steep and more open toward the south of the range, and with more steep-sided valleys in the north of the range. Craigieburn Valley is a steep sided valley and runs in a general E - SE direction, backing on to the main axis of the Craigieburn Range (Anon., 1978). The study site (Craigieburn Valley Skifield) (Plate 2) was situated at the head of Craigieburn Valley (43°07'S and 171°42'E) at 1,400 m above sea level in Craigieburn Forest Park.

Plate 2. Craigieburn Valley Skifield (study site indicated by arrow)
(photo: R. Greenaway)

Climate

The Craigieburn Range lies in the rain shadow of the Main Divide and, in Craigieburn Valley, the annual precipitation of 1500 - 1700 mm is less than half that at Arthur's Pass Village (Anon., 1978). The Craigieburn Range has a cool mountain climate. While snow may fall at any time of the year, there is no permanent snow in the area. The snowpack generally builds up from May - June onwards and thaws between October and January. The depth and cover of the snowpack varies considerably from year to year (Shanks *et al.,* 1990). Wind intensity is generally high and the channelling effects of the topography quite marked (Watson, 1970). In Broken River Valley, adjacent to Craigieburn Valley, wind gusts exceeding 108 km/h have been recorded in all months except February (McCracken, in Shanks *et al.*, 1990). As at Arthur's Pass Village, high diurnal and seasonal temperature fluctuations are typical. Mean monthly temperatures in the Craigieburn Range are 13.2°C in January and 2.0°C in July, but frosts occur throughout the year (Shanks *et al.*, 1990).

Human use

Craigieburn Valley Skifield was developed in 1953. Initially, access was only by foot, until the access road was finished in 1961 (Neutze, 1983). There are several private baches, and four ski lodges (owned by ski clubs). The buildings and skifield amenity area are at the timber line (1200 m), and some equipment sheds and shelters are situated on the higher slopes. From May to September, skifield staff live in the valley. Peak human attendance is during the winter months (June - August). During the rest of the year, the presence of people in the valley is infrequent and unpredictable. Outside the ski season, the access road is closed to the public. School groups and alpine club working parties use the facilities on the field, and private bach owners may be present at any time. During this study, the valley was a stop for one nature-tourism company (on a day-trip basis only). Tracks provided access for trampers and day-visitors.

2.1.2.2 Vegetation

Forest zone

Mountain beech* forest covers the slopes up to the timber line (1200 - 1400 m) with little undergrowth, and fewer species along the forest margins than are found in the wetter Arthur's Pass beech forests.

Subalpine shrub zone

The shrub zone in Craigieburn Valley is narrow and patchy, but is similar in species composition to the shrub zone above Arthur's Pass Village. Dominant species are snow totara*, turpentine scrub*, coprosmas*, mountain celery pine (*Phyllocladus alpinus**), hebes* and mountain cottonwood (*Cassinia vauvilliersii*).

Alpine tussock zone and fell fields

The subalpine shrub zone is patchy and merges with the much more extensive tussock zone. Mid ribbed (*Chionochloa pallens**) and slim snow tussocks (*C. macra*) predominate, but small patches of curled snow tussock (*C. crassiuscula*) also occur. These tussock areas support a variety of other alpine species, including several species of mountain daisy*, and, in some places, *Celmisia lyallii** is almost co-dominant with the tussocks. Spaniards or speargrass (*Aciphylla* spp.*) are also common in this zone. The fell fields and screes are sparsely vegetated.

Streamside vegetation

Along the streams, gentians*, buttercups* and kopoti (*Anisotome aromatica**) can be found, interspersed with native and naturalised grasses.

Revegetation plantings

Along the slopes of the true right of the Craigieburn Valley, lodgepole pine (*Pinus contorta*) and alder (*Alnus* sp.) grow on the scree slopes and in the tussock areas. These were planted in the 1950s as part of vegetation trials by the Forest Research Institute (Anon, 1978; Shanks *et al.*, 1990)

2.2 Methods

From March 1989 to February 1990 inclusive, monthly visits were made to the two study sites. At each of the study sites, there were four sampling stations (2.2.2). Each month two consecutive days were spent at the study sites (with the exception of May, when only one and a half days were spent at Craigieburn Valley). One of these days the primary focus was to carry out hourly counts at all sampling stations (chapter 3). The other day was used to record activities of kea at the sites (chapter 4), but censuses were carried out when possible. Instantaneous sampling (Altmann, 1974; Martin & Bateson, 1986) was used for both the censuses and the activity budgets. Kea were banded in order to track their movements (3.3.4) and to assess behaviour of known kea, especially foraging and manipulative-play behaviours (4.3.3).

2.2.1 Banding

I used a manually operated dropnet to capture kea. To facilitate easy identification of individual kea, 12 mm and 6 mm plastic colour bands were used in conjunction with the individually numbered 12 mm alloy bands. Kea were weighed, measured, aged and sexed. Age and sex of kea were determined on the basis of differences in colouration and size (Bond, Wilson & Diamond, 1991). Kea were aged into four categories: fledglings, one year olds, immatures and adults. Fledglings may be almost as large as adult birds. The overall colouration of their feathers is similar to that of adults, except for the crown which is very much brighter and can appear almost lime-green at times. The cere, eye ring and lower mandible of fledglings are bright lemon yellow. One year olds still have the bright yellow cere, eye ring and lower mandible, but the light colour of the crown has disappeared. The yellow colour of the cere, eye ring and lower mandible darkens with age and it is thought to take approximately three years for the yellow to change to the grey to charcoal adult colouration. Immatures cannot be aged accurately, but were assumed to be older than one year and not older than four years. The cere, eye ring and lower mandible of adults (four years +) are

grey or charcoal. There appears to be no difference in colouration between the sexes of either immatures or adults. Kea are, however, sexually dimorphic in body size. Males are larger than females for all standard measurements, the difference being greatest with bill size (12%) and weight (18%) (Bond, Wilson & Diamond, 1991).

Between 1986 and the start of my study in 1989, 85 kea were banded within my study areas (26 had metal bands only, the others were colour banded). Many were banded in conjunction with other research (Brejaart, 1988; Bond, Wilson & Diamond, 1990; Diamond & Bond, 1991; Bond & Diamond, 1992). During the study period, an additional 41 kea were colour banded within the study areas. Some of these were banded by Diamond and Bond (1991) and others by the author. None were banded on days during which observations were made. During the same period (1986-1990), an additional 84 kea were banded elsewhere in Canterbury (DoC unpublished data; Wilson, 1990a,b).

Based on findings by Campbell (1976), Clarke (1970), Jackson (1960) and Wilson (1990a, 1990b), a distance of 50 km was considered a 'reasonable limit' of possible resightings from banding point. Kea banded at localities further than 50 km from the study sites were included in the pool of marked individuals that could be resighted only when there was evidence of travel to the study sites. Following sitings of kea banded at Mt Hutt during this study, the 16 kea banded at this site were included, increasing the pool of banded kea from which resightings were expected to 137 (Table 2.1). Five kea banded in the study area, but which were known to have died before this study, have been excluded from analysis.

Table 2.1. The pool of banded kea at various localities and times, which could be expected to be resighted

	*C'Valley	**A'Pass	#Castle Hill	##Mt Hutt
before study: metal only	18	7	1	0
before study: colour banded	12	38	4	16
during study: colour banded	10	31	0	0

* "C'Valley" comprises four banding sites (Craigieburn Valley Skifield, Broken River Valley Skifield, Craigieburn Forest Park Head Quarters and Cave Stream Picnic Area) within a 4-5 km radius.

** "A'Pass" comprises six banding sites (Arthur's Pass Village, Halpin's Creek Dump, Bottle Flat, Coach Road Rest Area, Edward's Hut and Goat Pass) within a 11-12 km radius.

\# Castle Hill Station is 12 km from Craigieburn Valley and 35 km from Arthur's Pass Village. The distance between.

Mount Hutt Skifield and Craigieburn Valley and Arthur's Pass Village is 40 and 60 km respectively.

2.2.2 Sampling stations

To carry out the censuses, I chose four sampling stations at each of the study sites. The sampling stations represented the various presumed attractions for kea at the different localities (Tables 2 & 3). The following were thought to be potential attractions for kea: rubbish bins (food scraps), vehicles, presence of people and tents (Clarke, 1970; DoC unpublished data; Grant, 1993; Jackson, 1962b, 1969; Wilson, pers. comm.). Observations during a previous study (Brejaart, 1988) and preliminary field work for this study confirmed these potential attractions. At Arthur's Pass, the motel (AP3), vehicles and people activity were thought to be the main attractions for kea. There are also some rubbish bins situated behind the motel, which could attract kea. The Visitor Centre (AP4) included the carpark and picnic area adjacent to the Centre as well as the day shelter and campsite across the road. The sampling station labelled 'shop' (AP5) comprised the wider area surrounding the shop and included several roadside rubbish bins, a lodge, two hostels and private residences. The

rubbish bins, as well as people activity in this area, were thought to be the main potential attractions for kea. The restaurant (AP6) covered the northern end of the village, and vehicles at the restaurant were expected to be attractive to kea. The sampling stations are all situated along the main road (Fig. 3a). The distances between AP3 and AP4; AP4 and AP5; AP5 and AP6 are 600, 450 and 200 m respectively.

Table 2.2 Sampling stations and presumed attractions for kea at Arthur's Pass Village.

Sampling station		Presumed attractions for kea
AP3	Motel	people present, rubbish bins, vehicles
AP4	Visitor Centre (picnic + campsite)	people present, rubbish bins, vehicles
AP5	Shop	people present, rubbish bins, vehicles
AP6	Restaurant	people present, vehicles

Table 2.3 Sampling stations and presumed attractions for kea at Craigieburn Valley

Sampling station		Presumed attractions for kea
CV1	Lincoln Lodge and carpark	people present, equipment, vehicle, garage
CV2	Ngahere Lodge	people present, equipment, weather station
CV3	Koroheke Lodge	people present
CV4	Ticket office	people present, equipment

All four observation stations at Craigieburn Valley were in the forest at the timber line (Fig. 3b). Distances between the stations were relatively small, averaging approximately 30 m. Generally speaking, there were no food scraps available at the site but, in winter, rubbish bags were stored in the garage at the carpark (CV1). A closed-off storage space underneath Ngahere Lodge (CV2) contained food while it was inhabited during the ski season.

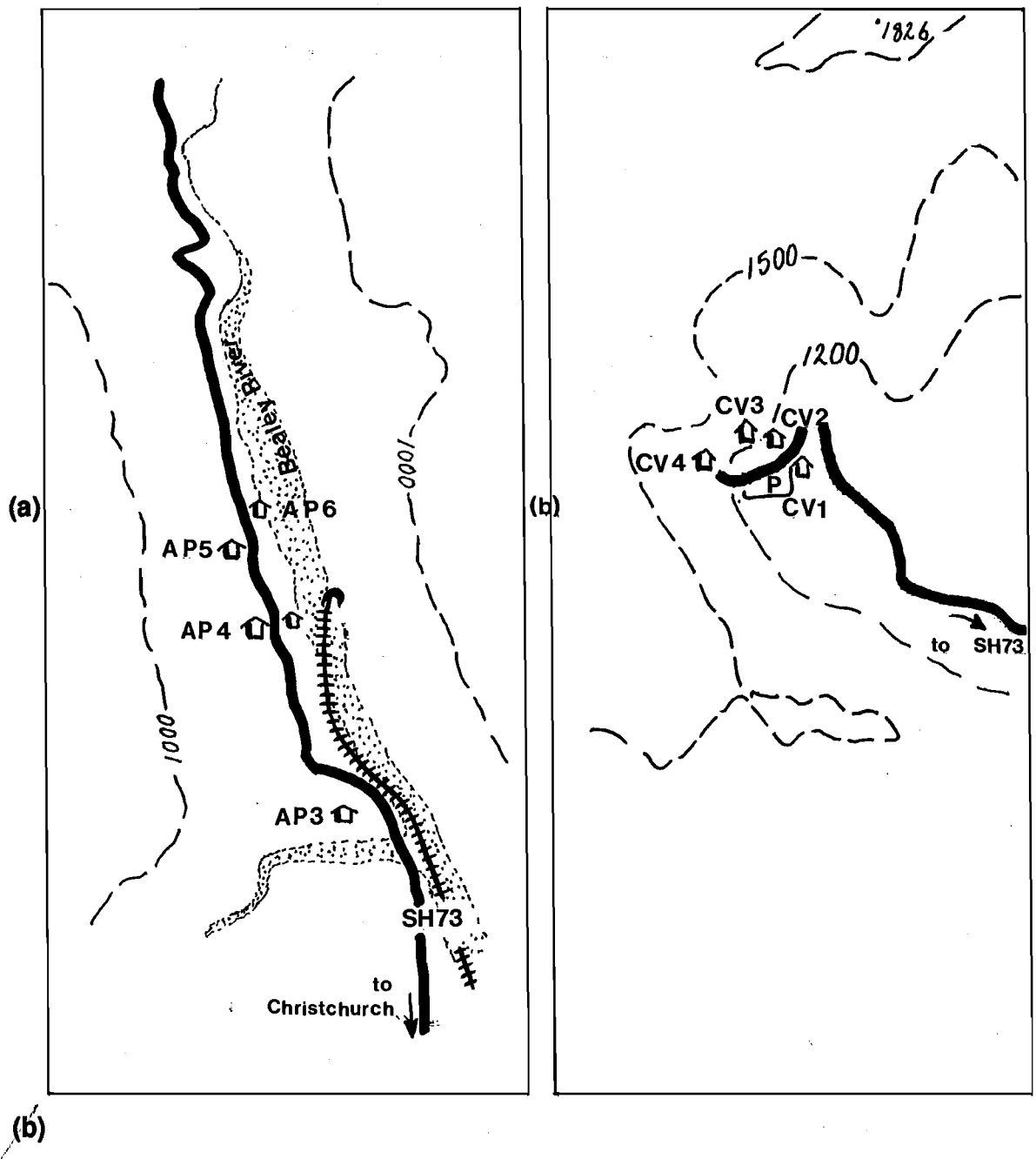


Figure 3. Sampling stations at (a) Arthur's Pass, and (b) Craigieburn Valley

At all sampling stations at both sites, permanent buildings and or structures were present. These could potentially attract kea because of their inquisitive nature.

At Arthur's Pass I censused two additional stations to collect complementary information on kea attendance at Arthur's Pass Village. A refuse dump, Halpins Creek Dump, 3.2 km down valley from Arthur's Pass Village, and a lookout point, Bottle Flat, 7 km north of the village at the head of the Otira Gorge were surveyed. Halpin's Creek Dump is situated on the valley floor, at an elevation of 700 m, and is surrounded by mountain beech forest. People activity at the dump is limited to the occasions people visit the dump, but food and rubbish were almost always present. Kea are known to forage at the dump, and are documented to have done so since the late 1950's (Jackson, 1962b, 1969). Bottle Flat is situated in a species rich subalpine shrub zone, on the western side of the Main Divide in the upper reaches of the Otira Valley at an elevation of 1,300 m. Further down the valley West Coast mixed podocarp hardwood forests prevail. Diversity of plant species at this site is much greater than in Arthur's Pass Village, and many of the species present are known food sources for kea. At Bottle Flat, people activity is frequent but unpredictable. Initially there were rubbish bins situated at the lookout, but these were removed in December 1989. Kea are known to frequent the lookout area (M. Harding, pers.comm.). Because of the travel time involved, and the major focus on the village, the refuse dump and Bottle Flat could not be sampled on an hourly basis. Where possible, these sites were sampled three times a day on census days, but in some months, adverse weather conditions and lack of transport prevented sampling.

2.2.3 Census and activity records

Observations by Jackson (1962b), Wilson (unpublished data) and myself, indicated that kea are active from daybreak to nightfall. During this study, I started observations one hour before sunrise, and ceased one hour after sunset. To circumvent the problems associated with longer daylight hours during summer, field days were divided into five

periods of equal length (hereafter referred to as *day periods*). This allowed comparison of data collected during different months, and pooling of data to examine diurnal patterns. Most of the time kea were encountered by themselves or in small groups. These groups appeared to be very fluid, and changed size in short periods of time. Hence I have chosen to refer to groups of kea rather than flocks.

2.3 Limitations

Detectability of the species

During previous studies (Brejaart, 1988; Wilson, 1990a,b), it became apparent that kea are often present but not detected until they call or fly away. While it is difficult to quantify the potential bias due to the detectability of the species, circumstantial evidence suggests that the numbers of kea recorded as present may be slightly conservative.

Identification of kea sighted

I aimed to identify all kea present by band number and/or colour combination, age and sex. Often, however, kea could not be identified with certainty. Reasons for this included kea being only partially visible, kea moving around or leaving the site during the census period, and poor light conditions. There were additional problems in identifying banded kea. The kea legs are not easily seen when the bird is perched and band numbers were hard to read. As a result, kea banded only with metal bands were not easily identified. For the previous study in the area (Brejaart, 1988), some kea shared colour band combinations, which allowed only banding locality to be identified. In addition, colour bands were lost due to the bands becoming brittle over time, and kea often manipulated or even removed their colour bands, resulting in an increase in shared or incomplete colour combinations. In those sections concerned with resightings (3.3.3.1) and movements (3.3.3.2) of banded kea, results are biased toward kea with intact individual colour combinations, since kea with metal bands only and those with double colour combinations were included only if the band number was read.

CHAPTER 3

ATTENDANCE AND MOVEMENT OF KEA AT ARTHUR'S PASS VILLAGE AND CRAIGIEBURN VALLEY

3.1 Introduction

Kea are omnivorous, but their natural diet is thought to be predominantly vegetarian (Brejaart, 1988). They exploit resources that are patchily distributed and the availability of which may change profoundly from season to season and from year to year. Movements of such opportunistic feeders are often dictated by food availability and species that display these characteristics are often highly mobile (Wiens, 1976). New food sources introduced into the habitat of such species are often quickly assessed and exploited. Some parrots are quick to exploit crops and other human provided foods, and the behaviour and movement of some species is affected by these foods (McInnes & Carne, 1978; Saunders, 1980; Cannon 1984; Long 1985; Ford 1989; Rowley 1990).

Kea are attracted to human occupied sites by artificial food supplements, provided both unintentionally in the form of rubbish and, to a lesser extent, intentionally in the form of handouts (Jackson 1960; Clarke 1970; Wilson 1990a; Grant 1993). Other factors thought to influence movements of kea, possibly in conjunction with the availability of anthropogenic foods, are human activity, snowcover (impacting on availability of natural foods), age, and breeding status of individual birds (Jackson 1960; Clarke 1970; Campbell 1976 ; Wilson 1990a). The aim of this part of the study was to evaluate patterns of attendance of kea at two human occupied sites: Arthur's Pass

Village and Craigieburn Valley. I assessed the relationship between the presence of kea and the presumed attractions (such as anthropogenic foods) for kea at the two sites. In addition movements of banded kea to, from, and between the sites were mapped.

3.2 Methods

3.2.1 Sampling method

Each month, two consecutive days were spent at each study site (2.2). On census days, the sampling stations were visited hourly or as close to hourly as possible. On days when kea activities were recorded (chapter 4), counts of the number of kea at the sampling stations were made as often as time allowed. During each count, five minutes were spent at each observation station to record data.

Using standardised data sheets, I recorded the following information:

* **date, sampling station** and **time.**
* subjective records of **weather** were made, consisting of:

  temperature: cold (below freezing level), cool (approx. 0-10^{0}C), mild (approx. 11-18^{0}C), warm (approx. 19-24^{0}C) and hot (approx. 25^{0}C and over).

  wind: calm, light, moderate, strong and gusty.

  cloud cover: visual assessment of the amount of cloud cover (0/8 = clear, 8/8 = overcast).

  precipitation: none, light rain, showers, steady rain, hail, sleet and snow.

  snow cover: visual assessment, measured in eighths (0/8 = no snow on the ground, 8/8 ground totally covered in snow). While I recorded snow cover separately for areas above and below the timber line, no distinction was made

between light and heavy snow cover (i.e light dusting of snow, 8/8 cover and heavy snow cover 8/8 were both recorded as 8/8).

* **number of kea present**: all kea seen at that locality during the hourly count. During any one count, no kea was knowingly counted twice.
* **identity of kea present**: colour combinations and/or band numbers of banded kea were recorded, as well as the age and sex of each unbanded kea. Criteria used to determine age and sex of the kea were described in 2.2.1.

Potential attractions for kea were categorized as follows:

* **people present**: none = no people, low = 1-5 people, med = 5-10 people, high = more than 10 people.
* **cars**: actual numbers present
* **food and rubbish**: three categories, 0, 1 and 2, were used to score presence of rubbish and/or anthropogenic food found away from rubbish bins, eg. along the road sides, left in picnic areas, and in cases of overflowing rubbish bins. Rubbish bins were regarded as attractive to kea at all times. 0=none, 1=inedible rubbish, 2=rubbish in which human food scraps were present.

The number of buses, picnics and tents at Arthur's Pass were recorded, but sample sizes were too small to include this data in the analysis.

Counts made on days that activities were recorded were pooled with the hourly counts from the associated census days. An average count per observation period was then calculated, for each of the five dayperiods (to correct for unequal sampling effort within the dayperiods), and for each of the months. These averages were used to analyse

diurnal and seasonal changes in numbers of kea, numbers of male and female adults, numbers of kea in the different age classes, and to analyse the influence of factors other than season and dayperiod on numbers of kea present (3.3.3). The significance of all factors were tested using factorial ANOVA's, allowing for unbalanced replication.

During this study, I recorded distances travelled by banded kea between successive sightings (3.3.4.2). Successive sightings included those where time of banding - whether before or during the study - is counted as the first sighting, and the first resighting during the study is counted as the next sighting. To get a more complete picture of distances travelled by kea, I collated sightings of banded kea from casual observations, using the same pool of 137 banded kea as used for this study. Resightings of banded kea outside the study period, or on days other than field days during the study were considered casual observations (sources: own observations, observations made by DoC staff, backcountry users, staff and users of skifields in the area and other researchers in the area). A banded kea was considered resighted if it was positively identified by band number and/or colour band combination, when seen alive, recaptured alive, or found dead. The period over which these observations were collected was 58 months (nearly five times as long as the period over which this study was carried out), from November 1986 to September 1991. By September 1991, there was no more structured research carried out in the area, and there was less intensive soliciting of information from backcountry users by DoC. The effects of age and sex on resightings were analysed using Chi square tests.

3.2.2 Limitations

Identification of kea

To analyse group composition (3.3.2), both banded and unbanded kea were included, provided they were positively identified for age and sex. While kea can be assigned to any of four age classes with relative certainty (2.2.1), for the purpose of age analysis, there seemed no advantage in separating one year old kea from the 2-3 year old kea. The category "immatures" thus comprised all kea identified as older than one year but not yet adult. To reduce possible errors related to the correct sexing of immature kea (especially the very young ones), only adult kea were included for the analysis of group composition by sex.

Observer presence

One of the aims of this study was to ascertain if human activity attracts kea (3.3.2). If this is so, the presence of kea was expected to coincide with the presence of people. The difficulty is that people are always present at Arthur's Pass Village, and that my presence could have attracted kea at Craigieburn Valley, where I was often the only person present. I have made the assumption that my presence at Craigieburn did not attract kea. To minimise the likelihood of attracting kea I did not take a vehicle to Craigieburn Valley. I also deleted records when kea were obviously reacting to me.

Sample sizes

While numbers of people present was categorised as none (0), low (1-5), medium (5-10) and high (10+) when data were collected, sample sizes for the category 'high' were small and, for analysis, the categories medium and high are combined (6+) (3.3.2.1, Table 3.1). Similarly, the actual number of cars was recorded when data were collected (range 2-26 at Arthur's Pass; 2-7 at Craigieburn), but sample sizes for more than two cars were small. For the purpose of analysis all observations where two or more cars were present are combined (3.3.2, Table 3.3).

3.3 Results

A total of 2601 hourly counts (1351 at Arthur's Pass; 1250 at Craigieburn Valley) were made during the 12 month study. The mean number of kea per observation period at Arthur's Pass (0.22 ±0.36) was significantly lower than at Craigieburn Valley (0.89±1.60); ($F=28.93$, $p<0.001$).

3.3.1 Seasonal and diurnal changes in kea numbers

Seasonal changes in kea abundance differed significantly between the two study sites (two-way ANOVA; $p<0.001$). At Arthur's Pass, kea were all but absent during the autumn months. With the onset of winter, kea numbers gradually increased to a peak in late spring (October-November). In summer, kea numbers declined again. At Craigieburn Valley, kea were most numerous in March. Numbers declined throughout autumn, with fewest kea observed in late autumn and winter (May-August). Kea numbers then increased in late spring and remained relatively high and stable throughout summer (Fig. 4).

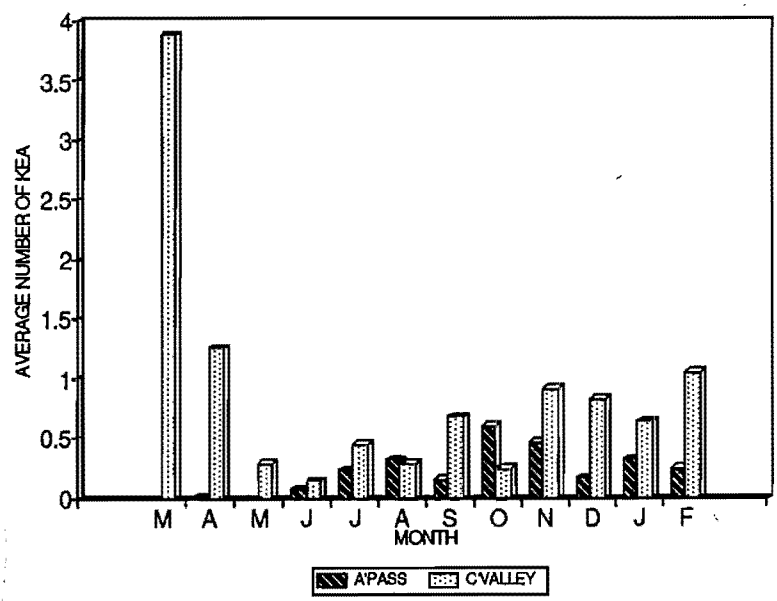


Figure 4 Average number of kea per observation period for each month at Arthur's Pass & Craigieburn.

At Arthur's Pass, daily peak times of attendance were the beginning and the end of the day. In contrast, at Craigieburn Valley, there was a peak at the beginning of the day that continued into the morning. From midday onwards, numbers declined and there was no evening peak (Fig. 5). These differences between the sites were not statistically significant.

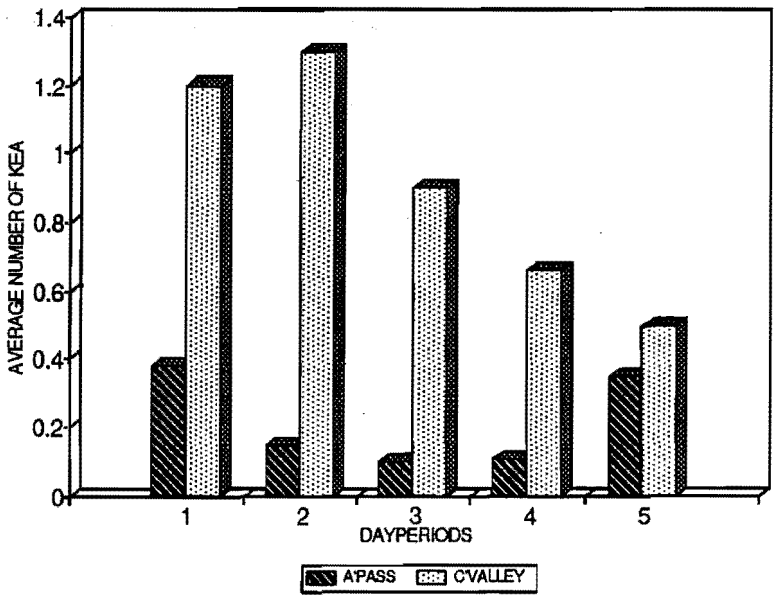
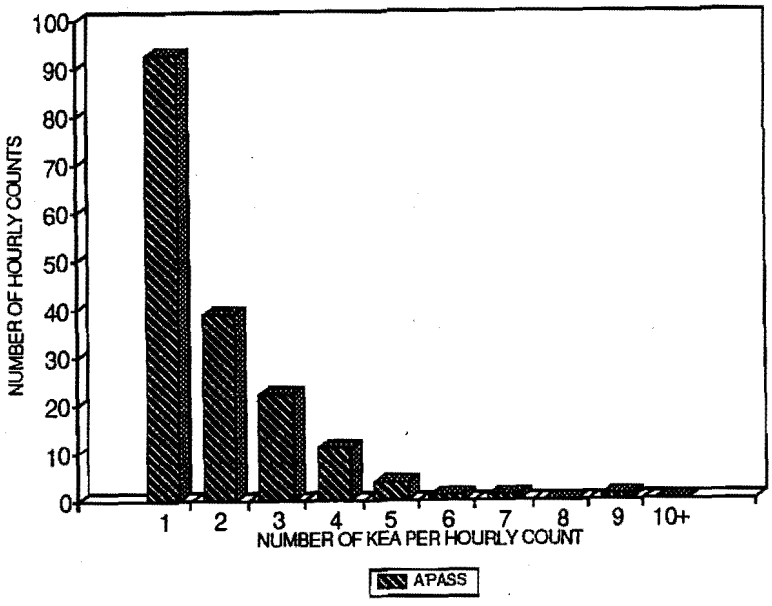


Figure 5 Average number of kea per observation period for each dayperiod (data pooled for all months) at Arthur's Pass and Craigieburn.

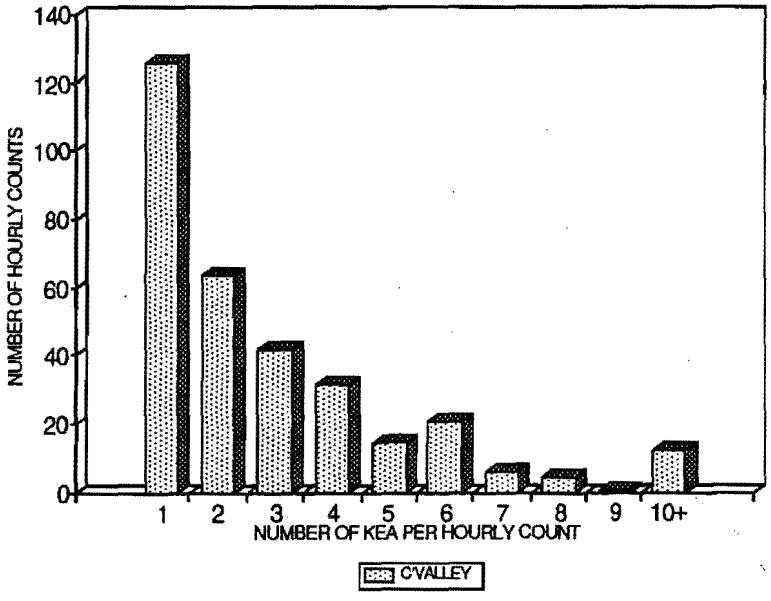
3.3.2 Group size and composition

Group size

Kea were recorded in only 172 of 1351 hourly counts (12.7%) at Arthur's Pass (Fig. 6a) and 324 of 1250 hourly counts (25.9%) at Craigieburn (Fig. 6b). When kea were present, the average group size was 1.9 (range 1-9) at Arthur's Pass and 3.0 (range 1-21) at Craigieburn Valley.



(a)



(b)

Figure 6 Frequency distribution of group sizes at (a) Arthur's Pass, and (b) Craigieburn Valley.

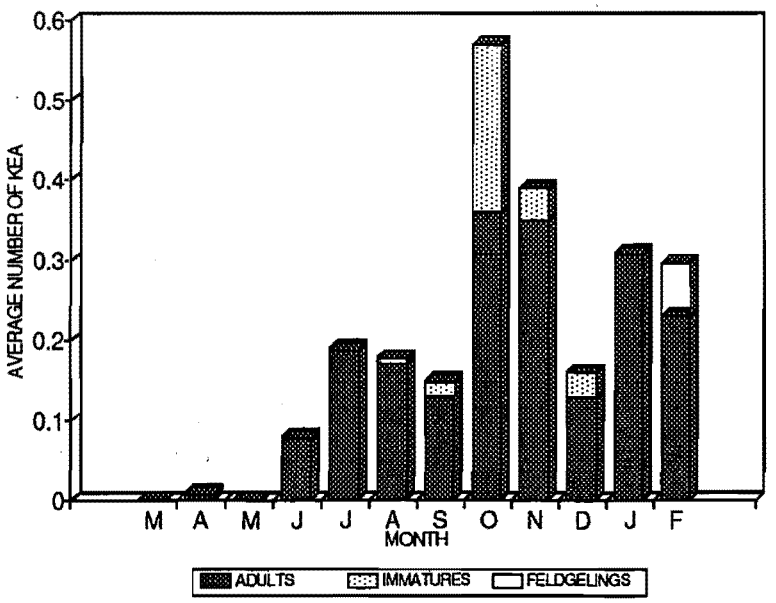
The Craigieburn Valley mean is strongly influenced by the large groups recorded in March. When these March data are omitted, the range for Craigieburn Valley for the rest of the year is 1-9 (the same as at Arthur's Pass), but the average (2.4) is still higher than at Arthur's Pass.

Age

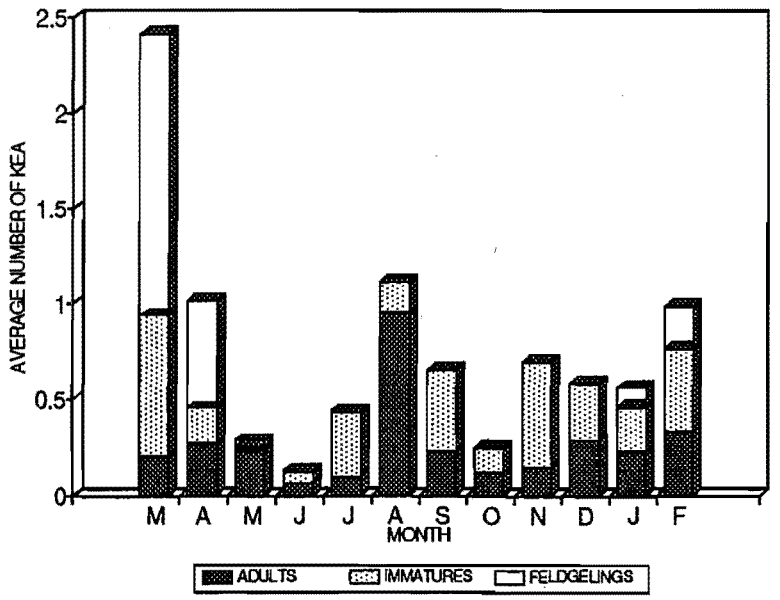
Kea not positively identified for age were excluded from this analysis. Most kea seen at Arthur's Pass were adults (Fig.7a). Only during February 1990, was a fledgling recorded at Arthur's Pass Village, although fledglings were seen at nearby Halpin's Creek Dump in March and June 1989, and in January and February 1990, and at Bottle Flat in January 1990. At Craigieburn, adult and immature kea were present each month, and fledglings were seen throughout autumn and summer (Fig.7b).

Sex

The mean number of male and female kea (adults only - 3.2.2) per observation period are shown for Arthur's Pass and Craigieburn (Figs. 8a and 8b respectively). Females were present during only 2 of 12 months at Arthur's Pass (yet at Halpin's Creek Dump females were seen in June, October, November and December 1989 and in January 1990; and at Bottle Flat in January and February 1990). At Craigieburn, females were present during 10 of 12 months.

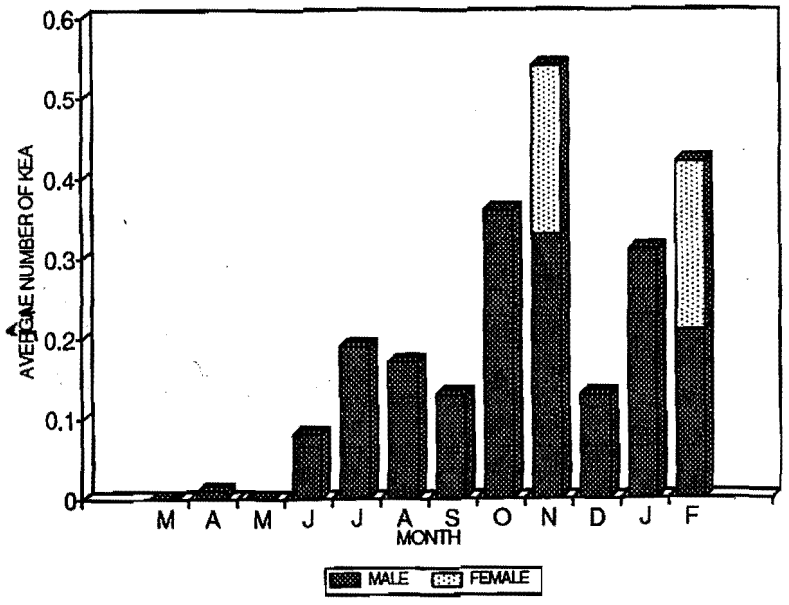


(a)

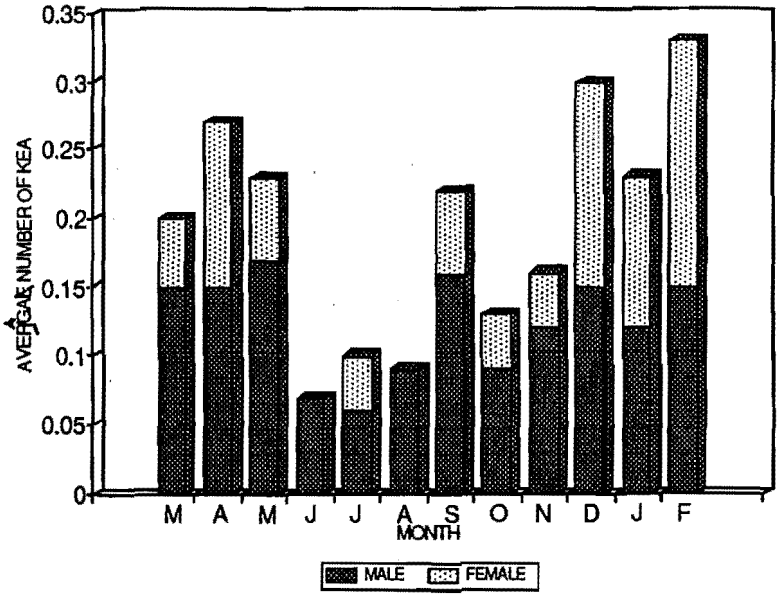


(b)

Figure 7 Average numbers of adults, immatures and fledglings per observation period for each month at (a) Arthur's Pass, and (b) Craigieburn Valley.



(a)



(b)

Figure 8 Average number of male and female kea per observation period for each month at (a) Arthur's Pass, and (b) Craigieburn.

3.3.3 Factors other than season and time of day which may influence numbers of kea at the study sites

3.3.3.1 Natural factors

It has been suggested that movements of kea may to some extent be dictated by natural environmental factors such as snow cover above the timber line (Clarke 1970; Jackson 1960). The relationship between mean numbers of kea present at each study site and snow cover, temperature, wind and precipitation was tested for each site but none of the results was statistically significant. There was a significant difference between the two sites in mean numbers of kea in relation to snow cover. At Arthur's Pass, the mean number of kea tended to decrease with the presence of snow, both for snow cover above the timber line only, and snow cover above and below the timber line. At Craigieburn, the mean number of kea decreased when there was snow cover above the timber line only, but increased when there was snow both above and below the timber line.

3.3.3.2 Anthropogenic factors.

Potential attractions for kea at the two study sites were people, vehicles, food and rubbish. Rubbish and food were not available to kea at Craigieburn Valley during this study so results for these two factors are presented for Arthur's Pass Village only.

People

The average number of kea tended to increase at both sites when more than 5 people were present but the trend is significant only for the Arthur's Pass data (Table 3.1).

Table 3.1. Mean numbers of kea (±SE) in relation to numbers of people present at Arthur's Pass and Craigieburn Valley (sample size in brackets).

Study site	Number of people present			One Way ANOVA
	0	1-5	6+	
Arthur's Pass	0.15±0.03 (267)	0.17±0.03 (155)	0.33±0.11 (55)	F=3.04 p=0.0477*
Craigieburn Valley	0.67±0.09 (354)	0.45±0.09 (59)	1.27±0.60 (13)	F=1.25 p=0.2192

Rubbish, food and cars

At Arthur's Pass, the number of kea also increased when food was present (Table 3.2). The effect of the number of cars on the number of kea present was significant ($p<0.05$) only at Craigieburn Valley, but this result was due to an increase when only one car was present (Table 3.3).

Table 3.2 Mean numbers of kea (±SE) in relation to the availability of anthropogenic foods at Arthur's Pass (sample size in brackets). Numbers of rubbish and food score the availability of rubbish and food: 0 = none, 1 = inedible rubbish only, 2 = at least some edible rubbish.

Study site	Rubbish and food present			One Way ANOVA
	0	1	2	
Arthur's Pass	0.15±0.02 (461)	0.80±0.18 (4)	1.06±0.35 (12)	F=26.30 p=0.000*

Table 3.3 **Mean numbers of kea (±SE) in relation to the number of cars present at Arthur's Pass and Craigieburn Valley (sample size in brackets).**

Study site	Number of cars present			One Way ANOVA
	0	1	2+	
Arthur's Pass	0.15±0.02 (323)	0.38±0.20 (16)	0.23±0.05 (138)	F=2.66 p=0.0692
Craigieburn Valley	0.60±0.07 (375)	1.40±0.57 (27)	0.66±0.33 (24)	F=3.29 p=0.0373*

3.3.3.3 Within site variation in kea numbers

Kea displayed distinct preferences for some sampling stations at both study sites. The differences were statistically significant (one way ANOVA; $p < 0.001$) for both sites, but the results for Craigieburn Valley should be interpreted with caution because the sampling stations there averaged only 30 m apart.

Arthur's Pass Village

The shop was by far the most popular place for kea to visit. The Visitor Centre (picnic and campsite) ranked second (mean numbers of kea 0.46±0.07, and 0.17±0.03 respectively). These sites had the highest number of people present and the greatest availability of anthropogenic foods. The rubbish bins at the shop often contained food scraps, and some left-over food could sometimes be found outside the shelter opposite the Visitor Centre. In contrast, mean numbers of kea were very low at the motel (0.05±0.02) and restaurant (0.03±0.02), where people were less common and anthropogenic foods were not generally available to kea.

Craigieburn Valley

The mean number of kea was highest (1.24±0.23) at Ngahere Lodge. Food was not available for kea at this sampling station, and people were most commonly present in winter, but kea were found near the lodge all year. The lodge is situated on the edge of the carpark and is surrounded by tall mountain beech trees, one of which was a favourite perch for kea. The carpark (+ Lincoln Lodge) was the next most popular sampling station for kea (0.62±0.11), followed closely by Koroheke Lodge (0.51±0.09). At the ticket office, mean numbers of kea were considerably lower (0.15±0.07).

3.3.4 Movements of banded kea

3.3.4.1 Resightings of banded kea

Of the 96 kea banded before this study (within the study area and at Mt Hutt, 2.2.1), 33 were resighted during the study at Craigieburn Valley, Arthur's Pass, Halpin's Creek Dump and/or Bottle Flat. Some were seen on several days (maximum 20). Of the 41 kea banded within the study area during this study, 21 were resighted (maximum 14 resighting days per kea).

Effects of sex and age on resightings of kea

The total pool of banded kea comprised 111 males (81%) and 26 females (19%). Seventy five (54.7%) were adults and 62 (45.3%) were non-adults (immatures and fledglings). Females were far less likely to be resighted than males (Table 3.4a; X^2=5.48, p=0.019*, df=1) but there was no significant difference between the sightability of adults and non-adults (Table 3.4b; X^2=0.26, p=0.614, df=1).

Table 3.4 Effects of sex and age on the number of times banded kea were resighted

	Sex		Age	
	Male	Female	Adult	Non-adult
Never resighted	62 (55.9%)	21 (80.8%)	44 (58.6%)	39 (62.9%)
Resighted on one or more field days	49 (44.1%)	5 (19.2%)	31 (41.5%)	23 (37.1%)
Total	111	26	75	62

3.3.4.2 Movement between the study sites, and movement between the study sites and other locations.

Most kea (32 of the 54 resighted; 59%) were resighted only at their banding location. Of the remaining 22 kea, 8 were seen at their banding location plus at least one other study site, and 14 kea were resighted at the study sites but were banded elsewhere. For those kea that moved between their banding location and other sites, the distance over which they moved ranged from 1.2 to 60 km between successive sightings. The largest recorded distance moved was 60 km by band number L-15023. This kea was banded at Mt Hutt Skifield in August 1988 and was resighted at the Halpin's Creek Dump in December 1989. When banded, L-15023 was described as a juvenile (= one year old) female. When resighted, this female would still have been immature (and presumably not breeding). The other four female kea resighted during the study (2 adults and 2 fledglings), were seen only at their banding location. Movements of kea according to resightings in this study are listed in Table 3.5. Fig.9 (pg 38) is a schematic representation of these movements.

Table 3.5. Travel of banded kea between and to the study sites.

Banding location	Resighting location	Distance (km)	Number of kea
	Kea banded at the study sites, resighted at their banding location only		
Arthur's Pass Village	APV	0	5
Halpin's Creek Dump	HC Dump	0	19
Bottle Flat	B'Flat	0	2
Craigieburn Valley	C'Valley	0	6
	Kea banded at the study sites, resighted at their banding location and at least one other location		
Halpin's Creek Dump	HC Dump & APV	0, 3.2	5
Halpin's Creek Dump	HC Dump & C'Valley	0, 20	2
Arthur's Pass Village	APV & HC Dump & B'Flat	0, 3.2, 6.8	1
	Kea banded at the study sites or at alternative banding sites, resighted during the study only at locations other than their banding location		
Halpin's Creek Dump	APV	3.2	3
Goat Pass	APV	6.8	1
Mt Hutt	HC Dump	60	1
Coach Road	HC Dump	1.2	1
Arthur's Pass Village	B'Flat	6.8	1
Halpin's Creek Dump	B'Flat	10	2
CFP Visitor Centre	C'Valley	4.5	4
Cave Stream	C'Valley	4.5	1

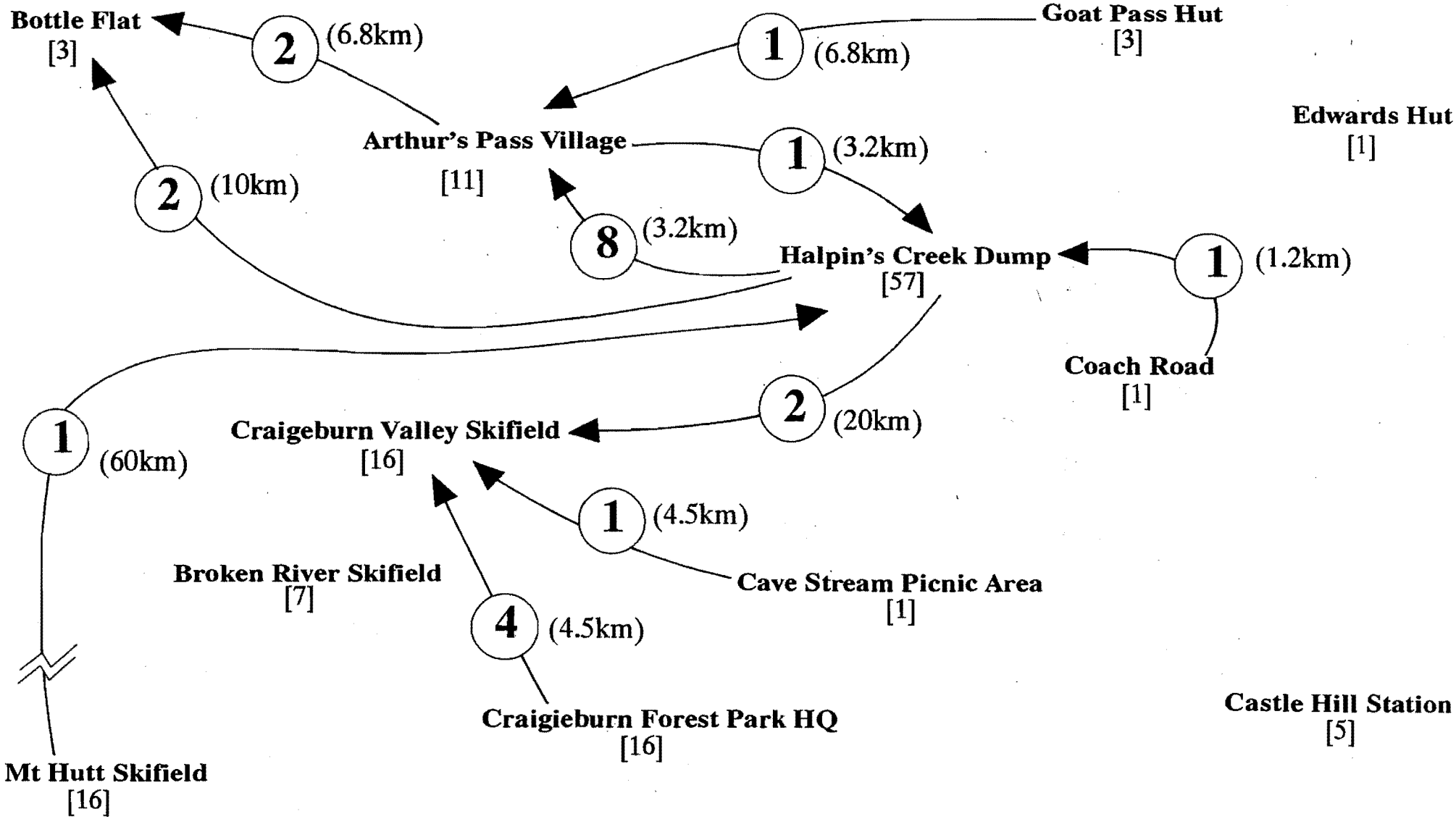


Fig 9. Movements of banded kea recorded during the study period (map not to scale)

(n) = number of kea that moved; (..km) = distance; [n] = number banded at site. Direction of arrow is away from the banding site

Sightings of banded kea from casual observations showed that 93 of the 137 kea (67.9%) were resighted over a period of 58 months (compared with 54 (37.4%) during the 12 month study). The vast majority of casual resightings were reported in the first 39 months, with resightings of only 10 banded kea reported in the period February 1990 to September 1991. Distances covered according to these sightings ranged from 0-98 km. Most resightings were within 12.5 km and 7.5 km of the point of banding in the Arthur's Pass and Craigieburn areas respectively. Three kea moved 20 km (between the Halpin's Creek Dump and Craigieburn Valley - one banded at Craigieburn, two at the dump), one kea banded at Bottle Flat was seen at Cheeseman skifield - 33 km away - and four kea moved 60 km (between the Halpin's Creek Dump and Mt Hutt skifield - two banded at each site). One kea, banded at Mt Hutt was resighted 98 km away at Arahura on the West Coast. By September 1991, 35 kea (25.5%) of the 137 kea banded had not been seen at all since banding.

3.4 Discussion

My study showed there were differences in numbers of kea present throughout the year, both within and between the study sites. At Craigieburn Valley, kea numbers peaked in March when the highest hourly count was 21. On the same day, but outside recording time, a group of 31 kea was seen. Such large groups of kea (10 - 31) were not seen at any other time of the year at Craigieburn Valley, and were never seen at Arthur's Pass Village.

Fluctuations in kea numbers, with occasional large peaks, have been recorded by other researchers. For example, Wilson (1990a) observed large congregations of kea in February at Mount Cook National Park in each of two years. Monthly records at

Cupola Basin indicated peak numbers of kea during January and February, with high numbers also seen in April and September (Clarke 1970). The number of kea seen at Lake Harris by Child (1978) ranged from 1-16. Peak numbers were recorded in February, eight and nine kea were seen in June and December, but no more than 5 kea were observed during any other month (Child 1978). In the same area, Campbell (1976) recorded peak kea numbers in May (15) and June (13). In these two studies peak numbers of kea were seen during late summer and early autumn, with occasional high counts in other months. Kea numbers may also vary markedly within individual months at the same site. Campbell (1976) recorded a maximum of 15 kea in May 1976 and 13 kea in June 1976, while Child (1978) recorded only three and eight kea respectively for the same months of that year. Jackson (1969) suggested that the large flocks of wandering kea which he observed in winter, comprised immatures that would settle elsewhere in spring.

Clarke (1970) attributed the peak numbers of kea seen during his study to visiting groups of kea. My observations suggest that the high numbers of kea observed in March at Craigieburn resulted from a combination of visiting groups of kea comprising many immatures and high numbers of fledglings at the site (3.3.2). Not all kea present at the time could be positively identified, but at least half of the kea observed were fledglings and immatures. Since few of these kea were banded, it is not known where the visiting kea came from. Fledglings remained in Craigieburn Valley during the rest of autumn (April & May), but were not observed during winter and spring (June - November). The increase in kea numbers following spring was apparently due to the number of females visiting the site together with fledglings. Both age groups increased gradually as summer progressed.

At Arthur's Pass Village, there was no peak in kea numbers similar to that described for Craigieburn Valley. Virtually none were present in the village in autumn, although kea could be heard on the steep slopes and bluffs above the village. Numbers at the village increased gradually over winter, were highest in spring, and declined again over summer. Few females and fledglings were ever seen in the village, but both females and fledglings were seen at Halpin's Creek Dump and at Bottle Flat. Of the two study sites, Arthur's Pass may be considered the more modified habitat for kea. It is possible that kea are attracted to the site mostly by seasonal availability of anthropogenic foods. The strong correlation between availability of anthropogenic foods and kea numbers supports this.

During winter, when snow cover above the timber line is heavy, few kea are seen above the timber line, except where they congregate at ski huts (Jackson 1960; Clarke 1970). Both authors suggested that kea are attracted to ski fields in winter because of the availability of anthropogenic foods. However, during this study, kea numbers at Craigieburn Valley were lowest in winter. Mild winter weather in 1989 resulted in only light snow cover above the timber line and relatively few skiers used the Valley and they did not feed kea. Thus, anthropogenic foods were not available to kea at the ski field that winter. At Arthur's Pass Village, kea numbers increased in winter as snow cover above the timber line increased, but they did not decline again in spring when the snow melted.

Diurnal patterns of kea numbers differed greatly between the sites, which may reflect differences in altitude and/or availability of anthropogenic foods between the sites. Peak numbers of kea at Arthur's Pass Village, at the beginning and the end of the day,

could reflect a crepuscular foraging pattern common to many animal species. At Mt. Cook, Wilson (unpublished data) observed the same pattern, with kea visiting the Hermitage at the beginning and end of the day to feed on anthropogenic foods. At Craigieburn Valley, the less modified of the two study sites, kea may spend all or most of the day there, so the diurnal pattern is less marked. No comparative data are available from other sites similar to Craigieburn Valley.

My observations showed that the groups of kea using the two study sites differed greatly in age and sex composition. Arthur's Pass was visited predominantly by adult male kea, and fledglings were virtually absent. Yet "family groups", comprising kea of both sexes and all ages were seen at Bottle Flat in February 1990. Based on their studies at the Halpin's Creek Dump, Bond & Diamond (1992) described fledging to be at its peak in January 1990. The low numbers of immature kea, and the absence of females and fledglings at Arthur's Pass, are difficult to interpret. Family groups were observed at Craigieburn in autumn and summer and, throughout most of the year both sexes, adults as well as immatures, were recorded. Wilson (unpublished data) found that, at Mt Cook, breeding birds of both sexes tend to remain within 1.5 km of their nest. However, breeding kea were resighted between 6 and 15 km from their nests in the Nelson Lakes area (G. Elliott pers.comm.). The presence of fledglings at Craigieburn at the beginning and the end of the study period suggests that kea breed in or near Craigieburn Valley. The absence of female kea at Craigieburn in June and August is probably related to breeding activity. Eggs are laid from July through to January, but mostly in July and August (Jackson 1960; Wilson & Brejaart 1992). Once incubation has started, female kea are unlikely to leave the nest until the chicks are several weeks old (Jackson 1960; Wilson unpublished data). Fledglings were first seen at Craigieburn in December. The female kea present in July may have been

non-breeders, or breeders that had not yet laid eggs. The average number of kea tended to increase at both sites when there were more than five people present at both sites, but this result was significant only for the Arthur's Pass data. This is not surprising for two reasons: first, at Arthur's Pass, people may be associated with food through rubbish (and sometimes handouts), but at Craigieburn Valley rubbish and handouts were seldom available during this study. Secondly, a large part of the adult kea population at Craigieburn Valley is female. Observations made before and during this study by myself and Wilson (unpublished data) showed that female kea are both less likely to react to and take advantage of people than male kea.

The difference in sightability between females and males is not unexpected. The ratio of male:female kea banded before and during this study (N=137) is 4.27:1. While this is due, in part, to the wary nature of the females (when females were present, they were always more difficult to catch), females were not seen nearly as often as males. This agrees with observations by Bond & Diamond (1992).

Movements of banded kea suggest that kea could have overlapping home ranges. This is supported by sightings of family groups at Craigieburn and at Bottle Flat. When fledglings were seen, it was common to see more than three (up to eight) at any one time. Yet, Wilson (in Wilson & Brejaart 1992) found that most clutches fledged two or three chicks. This suggests that kea from two or even three 'families' were seen together.

The overall distances over which kea were found to travel in this study, (range 0-60 km), were mostly within the range (0-25 km) observed by other researchers (Bond &

Diamond 1992; Campbell 1976; Clarke 1970; Jackson 1960; Wilson 1990a). The exception was the female banded at Mt Hutt and resighted at the Halpin's Creek Dump, 60 km away. Travel within an area of about a 12 km radius was relatively common (51 out of 54 kea resighted in my study and 82 out of 93 kea resighted casually, were seen within a 12 km radius of point of banding). During my study, only two banded kea travelled between the study sites. An additional three kea are known to have travelled between the study sites outside my study period. Overall, casual resightings supported the findings on movements made during the study period, but more long distance movements were recorded. These results indicate that kea possibly have large home ranges, which may include human occupied sites.

CHAPTER 4

ACTIVITIES OF KEA AT ARTHUR'S PASS AND CRAIGIEBURN

4.1 Introduction

At human occupied sites, kea readily investigate structures, equipment and vehicles. This behaviour often results in damage to property and, sometimes, in injury to or death of kea (DoC unpublished data, Grant 1993, Jackson 1969). It is often assumed that kea at human occupied sites can meet their daily energy requirements in a relatively short time by feeding on anthropogenic foods (Table 4.9), which are generally of a higher calorific value than natural foods. Time which might otherwise be spent feeding, can thus be spent investigating structures, equipment and vehicles (Grant 1993). It has also been suggested that inquisitiveness is an adaptive strategy for kea, and that they regard natural and manufactured objects as potential resources to be investigated (Diamond & Bond 1991). Kubat (1990) suggested that curiosity and the resulting manipulation of objects is part of the development of young kea. Kubat found that kea in captivity were attracted to novel objects, especially those they could manipulate.

Information on activities of kea at human occupied sites has not previously been quantified. My aim was to detail activity budgets of kea at Arthur's Pass Village and Craigieburn Valley Skifield. I anticipated differences in kea behaviour between the two sites, especially in foraging and manipulative behaviours, both of which may be influenced by the availability of anthropogenic foods. At Arthur's Pass foraging and

manipulative-play were expected to be common activities directed mainly toward anthropogenic foods and human made objects. I expected foraging on anthropogenic foods at Craigieburn to be an important activity only in winter, when people were present. Kea at that site were expected to focus manipulative-play activities on natural objects.

I investigated whether those kea that foraged on anthropogenic foods subsequently engaged in manipulative-play behaviours.

4.2 Methods and data analysis

4.2.1 Methods

Activities were recorded on one day each month throughout the day, and on census days (3.2) as often as time allowed. Observations were made in all weather conditions that allowed observation of kea. Once located, kea were observed throughout the study area, for 10 minute "observation periods". Sometimes up to three kea could be observed simultaneously. When more than two kea were present, I collected data on as many individuals of all ages and both sexes as possible.

For each observation period, the data recorded included date, time, weather, sampling station, number of kea present and identity of all kea present (band numbers, colour band combinations or age and sex of unbanded kea). Observations were made with 8 x 45 binoculars and a 20 x 50 spotting telescope. Kea activities were recorded using instantaneous sampling (Altmann 1974, Tyler 1979), at 30 second intervals, using eight predetermined activity categories. These categories were adapted from Potts' (1969, 1976, 1977) studies on kea, Magrath & Lill's (1983, 1985) work on crimson

rosellas (*Platycercus elegans*), and work by O'Donnell & Dilks (1988). Before final analysis, I reconciled the categories I had used with those described by Rowley (1990) for galahs. Detailed structural behaviours were recorded on standardised data sheets. These were collapsed into eight categories of functional behaviours (Martin & Bateson 1986) for analysis. These eight functional behaviours are shown below with the structural behaviours they included.

* **Body maintenance**: Shaking, stretching, scratching, bill-wipes, foot & leg nibbles, auto preening, defaecation, sneezing, jaw stretching and bill grinding (kea were never observed bathing).
* **Vocalising**: Calling while perched or moving. Calling was classified as social interaction when it could be established that it was part of an interaction with other kea (mostly when kea were seen in pairs or groups).
* **Foraging**: Searching for food, feeding and drinking.
* **Locomotion**: Walking, hopping, climbing, gliding and flight. These activities were classed as locomotion only when they were not obviously part of any other activity.
* **Manipulative and play behaviour**: Behaviours in this category (with the possible exception of chewing) were those that were not obviously directed to one of the other functional behaviours. Kea were observed playing alone, in groups, and both with or without objects. Play behaviours included fun-fighting (Potts 1969), acrobatics (Rowley 1990) and kea playing with their mirror image at glass doors at the skifield. Manipulative behaviours included chewing, pecking, pulling, throwing and tearing at objects. These behaviours were sometimes repetitive and sometimes appeared inquisitive in nature. Rowley (1990) labelled chewing

behaviours as part of body care (beak maintenance) for galahs. Likewise, Magrath & Lill (1983) described 'billing' (pecking at or grasping dead or live branches - or other objects) as having a possible function in beak maintenance or even foraging for crimson rosellas. While this may also be the case with kea, manipulation of objects is thought to be an adaptive strategy and part of the development of young kea (Diamond & Bond 1991, Kubat 1990). For the purpose of this study billing and chewing of objects were categorised as manipulative behaviour.

* **Perching**: Perched while non active but alert, or awake and relaxed but inert with their eyes either open or half closed. Only once was a kea seen fast asleep.
* **People Interaction**: Any interactions of kea with people. This included kea investigating people, and kea "performing" for people when photographed or fed.
* **Social Interaction**: Interactions between two or more kea, including aggressive, submissive, courtship, and recognition behaviours, as well as interactive vocalising and allopreening. The investigation of manipulative-play behaviours was one of the prime objectives of this study, and these behaviours were recorded in a category of their own, rather than included in social interactions.

Feeding records and records of instances where kea were fed by people were collected throughout the study. Any damage to human property by kea was also noted. I also left "kea-incident logs" with DoC staff for the duration of the study, and requested that any incidents involving kea, whether observed by D0C staff or reported by the public, be recorded in them. Kea incidents included kea damage to gear and vehicles, and injuries to or deaths of kea.

4.2.2 Sampling method

I decided to use instantaneous sampling (Altmann 1974, Tyler 1979), because the behaviours I was interested in were easily distinguished and the method allowed me to observe several individuals simultaneously. This sampling method tends to underestimate the percentage of time for rare and short duration behaviours, and overestimate behaviours of moderate frequency and long duration (Tacha, Vohs & Iverson, 1985). To remedy this as much as possible, I apportioned an interval between observations of 30 seconds, the shortest interval that allowed me to follow kea when this was necessary. The structural behaviours recorded included both short and moderate duration behaviours for all categories except perching, which was the only long duration behaviour.

Unless I observed them from a distance, with a telescope, kea were inevitably aware of my presence. To minimise bias, no observations were made when kea behaviour was visibly influenced by my presence.

4.2.3 Data analysis

My aim was to observe as many kea as possible using 10 minute observation periods (4.2.1). However, it was not always possible to keep individuals in sight for this long. For analysis, observation periods of less than 2 minutes were discarded. The spread of observation periods of different durations between 2-10 minutes was relatively similar at the two sites. Observation methods used at both sites were identical, and the chances of observing any of the types of behaviours was the same for both sites.

Of the total number of observation periods, 40.8% of the data were contributed by banded kea. Many of these kea were seen only a few times. This made it impossible to calculate weighted averages across individuals. The use of repeated measures from the same individuals tends to inflate the sample size (Machlis & Dodd, 1985). Therefore I accepted only a limited number of repeat measures from certain individuals, with the following condition: for identified individuals, I included only one observation period per dayperiod to test for differences in behaviours between the study sites, seasons and dayperiods. This reduced the proportion of observation periods of banded individuals from 40.8% to 27%, thus minimizing disproportional contributions to the data set by a small number of individuals. Although this means that all observations are not truly independent, the restricted number of repeat observations on the same individuals meant that, by and large, individual observation periods could be treated as relatively independent measurements. It is almost certain that some kea contributed more to the data set than others. However, during each dayperiod an effort was made to sample all kea present. This, and the large number of observations made at different times, helped overcome most of the bias introduced by using all data.

Sample sizes for the categories: Calling, People Interaction, and Social Interaction were small (in total accounting for only 10% of observations), so these categories were not analysed.

Fledglings and females were virtually absent at Arthur's Pass and only three kea were observed during autumn at Arthur's Pass. Resulting sample sizes for particular effects and combinations were small. Thus, log linear methods could not be usefully

interpreted, and Pearson Chi-square tests (with Yates corrections as appropriate) were used to analyse the data. Mean weights of banded kea were compared between age, sex, season and site using a factorial anova.

For analysis concerning the relationship between foraging and manipulative-play behaviours, and the nature of these behaviours, all observation periods in which either or both of these behaviours occurred were used. Each observation period was coded according to whether or not foraging and/or manipulative-play behaviours were recorded during the period. The three categories were *foraging*: periods during which kea were engaged in foraging; *manipulative*: periods during which kea were engaged in manipulative play which was not directed toward food; *foraging-play*: periods in which kea engaged in both behaviours.

4.3 Results

During the study, I made a total of 2607 instantaneous observations (162 observation periods) at Arthur's Pass Village and 5172 at Craigieburn Valley (343 observation periods). In autumn at Arthur's Pass, there were 27 observations of only two kea. Furthermore, females and fledglings were seldom seen at Arthur's Pass. Thus, between-site and seasonal comparisons were made only for males of two age groups (adults and immatures) and three seasons (winter, spring and summer).

The proportion of observations in the age and season classes differed significantly between the two sites (χ^2=83.92 and χ^2=22.25 respectively, $p<0.001$, df=1 for both). In addition, the proportion of observations in each age class differed significantly with season (χ^2= 24.31, $p<0.001$, df=1), as a product of the concentration of observations on immature kea in spring. To minimise confounding effects due to these interactions,

between site comparisons were carried out separately for adult and immature males, and differences in activities between the two age groups were analyzed per site only. Seasonal differences between the sites were tested for only adults.

4.3.1 Differences in activities by male kea between the study sites and between seasons.

Analysis of data pooled for three seasons (winter, spring and summer) is presented in Table 4.1. For adult males, the only significant differences between the sites were in body maintenance, which was highest at Craigieburn (Yates corrected χ^2=3.9, p<0.05, df=1), and in locomotion, which was highest at Arthur's Pass (χ^2 4.7, p<0.05, df=1). For immature males, no significant differences were found but this may be due to the small sample sizes for immatures at Arthur's Pass (N=15). No differences were apparent for either of the categories of greatest interest: foraging and manipulative behaviours.

Table 4.1 Observed frequencies and corresponding percentages of activities of adult and immature male kea at Arthur's Pass (AP) and Craigieburn (CV) (winter, spring and summer data pooled). (Key to behaviour categories: BOM = body maintenance, FOR = foraging, LOC = locomotion, M/P = manipulative-play, PER = perched.)

	Adult males					Immature males				
Behaviour	AP	%	CV	%	P	AP	%	CV	%	P
BOM	0	(0.0)	3	(7.3)	0.047*	2	(13.3)	15	(16.0)	1.000
FOR	9	(10.3)	5	(12.8)	0.919	3	(20.0)	7	(7.4)	0.279
LOC	24	(27.6)	4	(10.3)	0.031*	0	(0.0)	22	(23.4)	0.080
M/P	12	(13.8)	5	(12.8)	0.883	3	(20.0)	10	(10.6)	0.542
PER	36	(41.4)	18	(46.1)	0.617	5	(33.3)	32	(34.0)	0.957

Not all % columns add up to 100% because some categories were not analysed due to their small sample size (4.2.3)

The data presented in Table 4.1 were also used to examine differences in activities between adult and immature males at each of the sites. At Craigieburn, no significant differences in activities were detected between adults and immatures. At Arthur's Pass, body maintenance was highest for immatures, and locomotion was highest for adults (Yates corrected χ^2=13.0 and χ^2=4.0 respectively, $p<0.05$, df=1 for both).

There were sufficient data to investigate seasonal changes in activities only for adult males (Table 4.2). Seasonal differences were examined for each site. There were small fluctuations between seasons in the percentage frequencies of activities observed. However, these differences need to be interpreted with caution because sample sizes were small, especially at Craigieburn. At Arthur's Pass, kea foraged most in summer, and the proportion of manipulative-play behaviours was highest in spring. The percentage perching was highest in winter and lowest in spring (Table 4.2, χ^2=7.703, $p<0.05$, df=2).

Table 4.2 **Number of observations and corresponding percentages of activities of adult male kea in winter (WI), spring (SP) and summer (SU) at Arthur's Pass and Craigieburn.** (WI = June, July, August; SP = September, October, November; SU = December, January, February. Key to behaviour categories: BOM = body maintenance, FOR = foraging, LOC = locomotion, M/P = manipulative / play, PER = perched.)

	Adults - Arthur's Pass						Adults - Craigieburn					
Behaviour	WI	%	SP	%	SU	% P	WI	%	SP	%	SU	% P
BOM	0 (0.0)		0 (0.0)		0 (0.0)		1 (16.7)		0 (0.0)		2 (9.1)	0.437
FOR	2 (5.6)		3 (11.5)		4 (16.0)	0.408	1 (16.7)		2 (18.2)		2 (9.1)	0.728
LOC	9 (25.0)		4 (15.4)		11 (44.0)	0.066	0 (0.)		1 (9.1)		3 (13.6)	0.614
M/P	3 (8.3)		5 (19.2)		4 (16.0)	0.438	1 (16.7)		1 (9.1)		3 (13.6)	0.982
PER	20 (55.6)		11 (42.3)		5 (20.0)	0.021*	3 (50.0)		5 (45.5)		10 (45.5)	0.979

Not all % columns add up to 100% because some categories were not analysed due to their small sample size (4.2.3)

The same data were rearranged to inspect differences in behaviour of adult males between sites within each season (Table 4.3). The significant differences in body maintenance and locomotion, which were detected in the overall between-site comparison for adult males (Table 4.1), were confined to winter and summer. In addition, the percentage of foraging behaviour was significantly higher at Craigieburn in winter (χ^2=6.4, p<0.05, df=1), manipulative-play behaviour was significantly higher at Arthur's Pass in spring (χ^2=4.2, p<0.05, df=1), and perching was higher at Craigieburn in summer (χ^2=14.7, p<0.05, df=1).

Table 4.3 **Percentages of observations on activities of adult male kea at Arthur's Pass and Craigieburn in winter (WI), spring (SP) and summer (SU).** (WI = June, July, August; SP = September, October, November; SU = December, January, February. Key to behaviour categories: BOM = body maintenance, FOR = foraging, LOC = locomotion, M/P = manipulative/play, PER = perched.)

	% observations								
	Winter			Spring			Summer		
Behaviour	AP	CV	P	AP	CV	P	AP	CV	P
BOM	0.0	16.7	0.000*	0	0		0	9.1	0.002*
FOR	5.6	16.7	0.011*	11.5	18.2	0.159	16.0	9.1	0.141
LOC	25.0	0.0	0.000*	15.4	9.1	0.191	44.0	13.6	0.000*
M/P	8.3	16.7	0.081	19.2	9.1	0.041*	16.0	13.6	0.566
PER	55.6	50.0	0.432	42.3	45.5	0.667	20.0	45.5	0.000*

4.3.2 The relationship between foraging and manipulative-play behaviours

Kea that were foraging were less likely to engage in manipulative-play behaviours than those kea that did not forage. Foraging and/or manipulative-play behaviours were observed during 126 out of 162 observation periods at Arthur's Pass (77.8%) and 216

out of 343 observation periods at Craigieburn Valley (63%). For both sites combined, in 164 periods neither behaviour was observed, foraging occurred in 113 periods, manipulative-play in 175, in 53 periods kea engaged in both behaviours. Analysis of these figures implies an inverse relationship between foraging and those manipulative-play behaviours that were not directed toward food (χ^2=17.4, p<0.001, df=1). This result is supported by a regression analysis (data log transformed), using all observations made on foraging and manipulative-play behaviours during 341 observation periods at both sites, which indicated a negative regression between the two behaviours. In this analysis there was no effect for site, age, season or dayperiod (p>0.05 for all). Furthermore, there was no sex effect at Craigieburn, but both male and female kea engaged significantly more in manipulative-play behaviour per observation period than in foraging (p<0.001 for both sexes).

When analyzed by site, using numbers of observation periods, the tendency for kea to engage in one of the activities (rather than both) during the same observation period remained at both sites, but was less pronounced at Craigieburn than at Arthur's Pass. The significant difference between the sites (χ^2=20.6, p< 0.001, df=3) was largely attributed to the significant difference between the four categories of observation periods at Arthur's Pass (χ^2=28.9, p<0.001, df=1) (Table 4.4).

Table 4.4 Percentage of observation periods in which foraging (FOR), manipulative (M/P), both (FORMP), or neither behaviours (NFNM) occurred at Arthur's Pass and Craigieburn Valley.

	% observations				
Site	NFNM	M/P	FOR	FORMP	P
Arthur's Pass	22.2	11.9	32.7	8	0.0000*
C'Valley	37	33.8	17.5	11.7	0.1910

For those observation periods in which foraging and/or manipulative behaviours occurred, differences between age, sex (Craigieburn only), season and dayperiod were tested. No significant differences were found at Arthur's Pass. At Craigieburn Valley, differences between male and female kea and between seasons were not significant. However, the percentage of foraging periods increased with age, while there was a corresponding decrease in the percentage of both manipulative and foraging-play periods (χ^2=14.2, p<0.01, df=1) (Table 4.5).

Table 4.5 Percentages of manipulative (M/P), foraging (FOR) and foraging-play (FORMP) periods for kea of three age classes at Craigieburn.

	% of observation periods		
Age	M/P	FOR	FORMP
Adult	49.4	40.5	10.1
Immature	54.3	23.5	22.2
Fledgling	59.3	14.8	25.9

The diurnal changes in behaviour at Craigieburn showed that kea engaged most often in manipulative-play behaviours at the beginning and the end of the day. The three middle dayperiods comprised most of the foraging periods. Differences were significant between dayperiods (χ^2=19.2, p< 0.05, df=4) (Table 4.6).

Table 4.6 Percentages of manipulative (M/P), foraging (FOR) and foraging-play (FORMP) periods for five dayperiods at Craigieburn (all seasons pooled).

Dayperiod	% of observation periods M/P	FOR	FORMP
1	71.7	26.1	2.2
2	43.1	29.2	27.8
3	46.5	27.9	25.6
4	53.6	35.7	10.7
5	64.0	16.0	20.0

I examined all data to assess if those banded kea which were observed foraging, engaged in manipulative-play behaviour, either later in the same dayperiod or later in the same day. However, there were insufficient sequential data on banded kea to proceed with this analysis.

4.3.3 The nature of foraging and manipulative-play behaviours

I wanted to establish if kea foraged successfully and what sort of foods they ate. Similarly, I tried to find out toward what kind of objects manipulative-play behaviours were directed. At Arthur's Pass, adult males accounted for 90.9% and 90.4% of all foraging and manipulative-play observation periods respectively, which prohibited comparisons between age groups and gender for these activities.

Foraging

On average, kea fed during 42.2% of foraging and/or foraging-play periods (hereafter referred to as feeding periods). Kea at Arthur's Pass, however, foraged successfully significantly more often than those at Craigieburn Valley (χ^2=8.7, p<0.01, df=1) (Table 4.7).

Table 4.7 Number of periods in which kea at Arthur's Pass and Craigieburn Valley were observed foraging and feeding. (both sexes and all age classes pooled for each of the sites).

Site	FORAGING		FEEDING		N
Arthur's Pass	29	(43.9%)	37	(56.1%)	66
Craigieburn Valley	67	(67.0%)	33	(33.0%)	100

Foods taken by kea were categorised as unidentified, human or natural. Kea fed mainly on human foods at Arthur's Pass and on natural foods at Craigieburn (χ^2=16.9, p< 0.001, df=2) (Table 4.8).

Table 4.8 Number of periods in which foods taken by kea at Arthur's Pass and Craigieburn Valley were unidentified (UF), human (HF) or natural (NF) (both sexes and all age classes pooled for each of the sites).

Site	UF	HF	NF
Arthur's Pass	5	26	6
Craigieburn Valley	5	8	20

There were no significant differences in foods taken at either of the study sites between seasons and dayperiods, or between ages and sex at Craigieburn. However, sample sizes were too small (range 0 - 23) to conclusively test the data. Table 4.9 lists the actual foods taken by kea at the two study sites during this study.

Plates 3 & 4. Kea feeding on anthropogenic food (*photos Robert Greenaway*)

Plate 5. Kea digging for insect larvae (*photo Robert Greenaway*)

Plate 6. Kea feeding on *Anisotome pilifera* (*photo Mike Harding*)

Plate 5. Kea digging for insect larvae (*photo Robert Greenaway*)

Plate 6. Kea feeding on *Anisotome pilifera* (*photo Mike Harding*)

Table 4.9 **Foods taken by kea at Arthur's Pass and Craigieburn Valley in autumn (AU), winter (WI), spring (SP) and summer(SU).** (Number of *observations* in brackets; * indicates instances when kea were fed by people).

Season	ARTHUR'S PASS	CRAIGIEBURN VALLEY
AU	peanuts (4) *	mountain beech (*Nothofagus solandri* var. *cliffortiodes*) - leaves (8) mountain celery pine (*Phyllocladus alpinus*) - cones (33) *Anisotome aromatica* - roots (15) *Celmisia lyallii* - leaf base & roots (17)
WI	mountain beech - leaves (4) apple (7) *Coprosma brunnea* - fruit (6)	mountain celery pine - seeds (26) carrot (2)
SP	cream cake (5) raspberry jam (8) frying fat (15) bread (6) * pastry (12) apple (7) *	bread (30) * carrot (2) * chicken (marrow from bones) (14) * insect larvae (species unidentified) (4)
SU	chocolate (1) * icecream (1) * bread (26) * crackers (4) * frying fat (20) potato chips (4) chicken & gravy (12) *Hieracium* sp. - leaves (4) mountain flax (*Phormium cookianum*) - nectar (16)	snow totara (*Podocarpus nivalis*) part taken unknown (6) mountain beech - leaves (4) *Hieracium* sp. - leaves (3) grass seeds (species unidentified) (3)

Weights

The differences in foods eaten by kea at the two study sites prompted me to compare weights of kea banded at the two study sites. The mean weight of kea banded at

Arthur's Pass was 936 g (SE 11.4, N=83), nearly 100 g more than the mean weight of kea banded at Craigieburn (835 g, SE 18.6, N=35), factorial anova; $P<0.001$. Mean weights for age classes, sexes and seasons are given in Table 4.10

Table 4.10 Mean weights of kea of three age classes (males and females), both sexes (all age classes) and in four seasons (all ages, males and females). Data for kea banded at Arthur's Pass and Craigieburn are combined.

Variable	MEAN WEIGHT (g)	SE	N	P
Age:				
Fledglings	830	30.5	19	
Immatures	888	16.0	55	
Adults	938	13.3	44	0.008
Sex:				
Males	951	10.2	103	
Females	820	23.2	15	0.000
Season:				
Autumn	905	86.1	6	
Winter	928	28.6	24	
Spring	869	16.3	36	
Summer	838	11.9	52	0.001

None of the interactions of any of the factors in Table 4.10 with site was statistically significant ($p>0.05$ for all factors). This implies that the differences between age groups, sex and season were consistent at both banding sites.

Manipulative-play behaviour

Manipulative-play activities were recorded in 73 observation periods at Arthur's Pass and in 155 observation periods at Craigieburn. The observation periods were labelled

according to the nature of the behaviour observed. In any one observation period, kea were identified as manipulating (or playing with) human-made objects (MPH), natural objects (MPN) or both (MPHN). As a part of any of these activities, kea could play alone, in pairs, or in small groups (up to seven kea). If kea played without objects, the period was categorised as playing with kea only (MPK). Table 4.11 shows the number and percentages of observations for all categories at both sites.

Table 4.11 Number and corresponding percentages of manipulative-play periods in which kea at Arthur's Pass and Craigieburn Valley were engaged in different manipulative behaviours. (both sexes and all age classes pooled for each of the sites. MPH = human objects, MPN = natural objects, MPHN=both human and natural, MPK = play with other kea or alone - no objects to play with).

Site	MPH	MPN	MPHN	MPK	TOTAL
Arthur's Pass	67 (91.8%)	3 (4.1%)	1 (1.4%)	2 (2.7%)	73
Craigieburn Valley	105 (67.8%)	19 (12.9%)	22 (14.2%)	9 (5.8%)	155

My main interest was in manipulative-play behaviours directed at objects, and the MPK category was excluded from comparative analysis. The difference in the nature of manipulative-play periods for the remaining three categories was significant between the sites (χ^2=15.09, p< 0.001, df=2) (Table 4.11).

At Craigieburn, fledglings manipulated almost exclusively human made objects, except in eight observation periods when they manipulated both human and natural objects. The difference in manipulative-play behaviours between three age classes, including fledglings, was significant (χ^2=10.6, p< 0.05, df=4) (Table 4.12). When fledglings were removed from the comparison, the age difference was marginally non-significant (χ^2=5.8, p=0.06, df=2).

Table 4.12 Number of periods and corresponding percentages in which kea of three age classes at Craigieburn Valley were engaged in manipulative-play behaviours. (Both sexes pooled. MPH = human objects, MPN =natural objects, MPHN = both human and natural).

Age	MPH	MPN	MPHN	TOTAL
Adults	26 (61.9%)	9 (21.4%)	7 (16.7%)	42
Immatures	43 (71.7%)	10 (16.7%)	7 (11.7%)	60
Fledglings	36 (81.8%)	0 (0.0%)	8 (18.2%)	44

There were no significant differences between males and females, seasons or dayperiods at Craigieburn. The Arthur's Pass data were insufficient to examine differences between seasons and dayperiods.

The category "human made objects" included buildings, rubbish bins and rubbish, vehicles, tents, and 'other'(the latter comprised building materials, clothing, tramping gear and tools). Tents, rubbish bins and rubbish were available only at Arthur's Pass. Table 4.13 lists percentage frequencies of manipulative activities directed at human made objects, based on all recorded observations. When manipulating human made objects, kea at Craigieburn directed most of their activities at objects in the category 'other'. At Arthur's Pass the category 'other' ranked equal with rubbish bins. Kea at both sites manipulated buildings and vehicles.

Table 4.13 Percentage frequencies with which kea at Arthur's Pass and Craigieburn Valley manipulated different "human made objects". (Both sexes and all age classes pooled for each of the sites.)

Site	% of observations					
	BUILDING	R/BIN	RUBBISH	VEHICLE	TENT	OTHER
Arthur's Pass	9.0	28.1	12.8	18.8	3.1	28.1
Craigieburn Valley	24.2	0.0	0.0	13.6	0.0	62.2

4.3.4 Kea Incidents

Damage to human property

Few kea incidents resulting in damage to human property were recorded during the observation periods. At Arthur's Pass, damage by kea was recorded twice in a single observation period in spring and nine times (three observation periods) in summer. At Craigieburn, kea were engaged in activities resulting in damage in 15 observations (three observation periods) in winter, with one observation in spring. Damage recorded during the study comprised the following:

Arthur's Pass
- close cell foam padding ripped off a trailer
- ripped bicycle seat
- holes in two tents
- a plastic water bottle taken from a tent and shredded.

Craigieburn Valley
- a metre rule was peeled off a snow stake at the weather station
- rubber was taken from a roof rack on a car.

In addition, a total of 23 incidents of kea damage were reported to DOC staff during the study period (11 of these occurred in Arthur's Pass Village, seven in the immediate

vicinity of the Village, five in Craigieburn Forest Park, none at Craigieburn Valley Skifield). These incidents are summarised as follows:

- damage to vehicles AP (6), CFP (0)
- damage to tents AP (11), CFP (0)
- damage to tramping gear AP (5), CFP (4)
- damage to other property AP (1), CFP (4).

Injuries and death of kea

During the study period, 10 kea were found dead at Arthur's Pass and one at Craigieburn Valley. At Craigieburn, one adult kea (sex unknown) flew into a garage door and subsequently died. The dead kea at Arthur's Pass comprised four adult males, two immature males, one adult and one immature (sex unknown) and two kea (age and sex unknown). Causes of death for the Arthur's Pass kea included roadkills (5), unidentified illness resulting in death (1), and ingestion of a rubbery substance (1). For the remaining three kea, no cause of death was recorded, and their deaths may not be related to human activity.

In addition to the dead kea, three injured kea were found. One immature male had its legs tangled up in nylon fishing line at Craigieburn Valley. Two injured kea (one immature male and one unidentified) were found at the Halpin's Creek Dump site at Arthur's Pass, but the cause of their injuries was unknown.

4.4 Discussion

It is generally assumed that the major attraction for kea at human occupied sites is anthropogenic food (Jackson 1960, Clarke 1970, Grant 1993), but information on the foraging activities of kea at human occupied sites is sparse and mostly anecdotal.

The two sites used in this study differed greatly in the anthropogenic foods available. At Arthur's Pass such foods were available to kea year round. This was not the case at Craigieburn Valley, where foods would normally be available in winter but not often at other times. In the winter of this study no anthropogenic food was available, although people visiting the site that spring were observed feeding kea. Contrary to my expectations, the differences in kea activities between the two sites were small, especially for those activity categories considered most important to this part of the study, foraging and manipulative-play.

If food is the main attraction for kea at Arthur's Pass, foraging could be expected to be an important, or at least a common activity there. This expectation would be supported by a high percentage of foraging observations, a high frequency of successful foraging, or by feeding on foods high in calorific value.

For adult males, proportion of foraging and manipulative-play activities were equally common at both sites. However, analysis of those observation periods (4.3.2) in which manipulative-play and/or foraging behaviours were observed, revealed that the proportion of foraging periods (as opposed to manipulative or foraging-play periods) at Arthur's Pass (42.1%) was much higher than at Craigieburn (27.9%). In addition, there were considerable differences between the two study sites, both in the percentage of successful foraging periods and the actual foods taken by kea (4.3.3). Overall, kea at Arthur's Pass were 1.7 times more likely to obtain food than those at Craigieburn. The food obtained by kea at Arthur's Pass was of higher calorific value than the foods obtained at Craigieburn. Kea at Arthur's Pass obtained a much higher return for less foraging effort.

During winter, Jackson (1960) and Clarke (1970) observed groups of scavenging kea, at Arthur's Pass Village and Mt Robert skifield (Nelson), respectively. It was thought that anthropogenic foods were the main attraction to these sites (Jackson 1960, Clarke 1970), but that kea were attracted also by human activity (Clarke 1970). Jackson (1960) suggested that winter is a time when natural foods for kea are scarce.

During my study, numbers of kea at both sites were lower in winter than in any of the other seasons (3.3.1). In winter, foraging activities were proportionally lower at Arthur's Pass than at Craigieburn, and kea at both sites were observed to utilise seasonally available natural foods (4.3.3). In spring kea foraged marginally more often at Craigieburn than at Arthur's Pass, but this was mainly a result of people feeding the kea. The highest percentage of foraging observations at Arthur's Pass was made in summer. In summer, there were more people at Arthur's Pass than at other times of the year, and rubbish and litter were most readily available. Throughout summer kea visiting Arthur's Pass village ate mainly anthropogenic foods, but they did feed on flax nectar when it was available.

Kea at Arthur's Pass were consistently heavier than those banded at Craigieburn, perhaps as a result of the anthropogenic foods available. I compared the Arthur's Pass and Craigieburn weights with mean weights of kea from Mt. Cook (Wilson unpublished data). At Mount Cook kea were banded at the Hermitage, where they feed on anthropogenic foods, and at Ball Shelter, where they feed predominantly on natural foods. Kea banded at the Hermitage were heavier than those banded at Ball Shelter, but the differences were not significant (mean weights were 901 gms (SE 16.4, N=52) and 862 gms (SE 12.7, N=50) at the respective sites), a smaller difference than that found between Arthur's Pass and Craigieburn. The Hermitage and

Ball shelter are marginally closer together than Craigieburn and Arthur's Pass (15 km versus 20 km). Resighting data (3.3.4.2) showed that few kea visit both Arthur's Pass and Craigieburn. A greater proportion of kea banded at Mt. Cook visited both the Hermitage and Ball Shelter (K-J Wilson, pers.comm.).

Kea reputedly investigate anything novel regardless of whether or not it is edible. I detailed the percentages of foraging, manipulative and foraging-play periods, for kea of three age classes at Craigieburn (4.3.2). For fledglings, only 14.8% of these periods were foraging periods. Nearly 60% were manipulative periods and 26% were foraging-play periods. The percentages of the manipulative and foraging-play periods decreased with age, while the percentage of foraging periods increased with age. This agrees with Diamond & Bond (1991) who also observed that kea spent less time manipulating and became more proficient at foraging with age.

Links between foraging and manipulative behaviours were inconclusive. Grant (1993) suggested that if kea feed on anthropogenic foods, it is likely that they will have 'spare time' which is spent investigating and manipulating human made objects. My observation periods (max. 10 minutes) were too short to obtain conclusive results. Resightings of banded kea after observation periods in which they had fed would have allowed this question to be addressed. However, the lack of such sequential data made it impossible to test the hypothesis that foraging on anthropogenic foods by kea is followed by manipulative-play behaviours. Results suggest that during this study anthropogenic foods were an attraction for kea at Arthur's Pass, but not at Craigieburn. Kubat (1990) suggested that the kea's inquisitiveness and the resulting manipulative behaviours are an adaptive strategy and an essential part of exploiting seasonally variable resources. Percentages of manipulative activities by adult male kea were

comparable between the sites (13.8% at Arthur's Pass and 12.8 % and Craigieburn). The objects toward which manipulative behaviours were directed differed between the sites. Kea at Arthur's Pass spent nearly all (91.8%) manipulative periods exploring and playing with "human made objects" (for Craigieburn the corresponding figure was 67.8%). Manipulation of natural objects was significantly less common at Arthur's Pass than at Craigieburn. These observations support the idea that kea manipulate any novel object, whether natural or human, regardless of food value.

Perching was the most common behaviour for both adult and immature male kea at both sites. This is in part a consequence of the observation method used (4.2.2). Perching was the only behaviour which was likely to last the duration of an observation period. Thus, any random sample from such a period would have been an observation on perching.

When comparing all behaviour categories for male kea (4.3.1), the only significant differences in activities between the sites were for adults for body maintenance and locomotion. Initially I assumed that the low incidence of body maintenance at Arthur's Pass was related to the low attendance of kea at the site during the middle of the day (the main roosting period for kea). At Craigieburn, however, where kea were present during the middle of the day in most months, the proportion of body maintenance records was lowest at this time of day. The percentage of locomotion for adult males was relatively high at Arthur's Pass. This is in agreement with the general impression I gained of kea at Arthur's Pass, being highly active, often pursuing food or entertainment. Few immature males were recorded at Arthur's Pass. Thus differences between immature males of both sites, and adult and immature males at Arthur's Pass are tentative only (4.3.1).

Damage to human property as a result of kea activity was more widespread than indicated by my observations. Kea appeared to cause more damage at Arthur's Pass than at Craigieburn, but this was largely due to the different human made objects present at the sites. At Craigieburn Valley a lot of kea-damage to the buildings was visible, although this was not reported in the kea incident logs.

Jackson recorded causes of death for 74 kea, which were banded over a 10 year period (1957-1967) in the Arthur's Pass area. Twenty nine of these were deliberately destroyed. Of the remaining 45, 14 died directly or indirectly, as a result of human activity (Jackson 1969). During my study, 10 kea were found dead and two injured at Arthur's Pass, while at Craigieburn Valley one kea was found dead and one injured. Seventeen other kea were found dead kea at Arthur's Pass, 13 during a 21 month period prior to, and 4 in seven months following this study. One kea was found dead prior to the study at Craigieburn. For 15 of all 29 dead kea and for all injuries, causes were related to human activity. Roadkill was the most common cause of death. At least some of these deaths and injuries are preventable.

CHAPTER 5

GENERAL DISCUSSION

Kea were observed at two study sites, Arthur's Pass Village and Craigieburn Valley Skifield. The two sites were of a very different nature. Arthur's Pass Village is situated on a valley floor, Craigieburn Valley Skifield is situated at and above the timber line. At Arthur's Pass, people were present all year round, and anthropogenic foods were available to kea at all times. At Craigieburn, small numbers of people were present in winter only, anthropogenic foods were available to kea in two months only. Patterns of seasonal and diurnal attendance of kea, and the nature of kea activities, differed between the sites. Numbers of kea, and age and sex composition of the groups varied greatly between the sites.

In this chapter I provide an overview of the findings of this study that were presented in the preceding chapters. I also identify hazards for kea at the study sites, and discuss options for kea-friendly habitat management.

5.1 Attendance and activities of kea at human occupied sites

At Arthur's Pass, kea fed predominantly on anthropogenic foods, but they did take seasonally available natural foods. Jackson (1969) suggested that natural foods for kea are scarce in winter, and that as a result, kea congregate at human occupied sites in winter.

During this study, kea were virtually absent at Arthur's Pass in autumn, some kea were present in all other seasons, and the highest numbers of kea were seen in late spring and summer. Kea were present in all months at Craigieburn, despite the limited availability of anthropogenic foods at the site. At Craigieburn kea ate natural foods, but did take anthropogenic foods when given the opportunity. Kea at Craigieburn

would probably use such foods more often if they were available. This is supported by casual observations made at other skifields in the area, where kea feed on anthropogenic foods. It is possible that anthropogenic foods were attracting kea to Arthur's Pass, but results did not support a similar interpretation for Craigieburn. However, during this study there was relatively little snow in winter, skifield operations were limited, so observations of kea behaviour made at Craigieburn may not be typical for that site in other years.

Kea observed at Arthur's Pass were almost exclusively adult males that were present mostly at the beginning and end of the day. At Craigieburn kea of both sexes and all ages were seen in most months of the study. The reason for these differences between the sites, in composition of the groups of kea, are not clear. Craigieburn appeared a far more 'natural' site, where family groups of kea were more or less resident. Diurnal patterns of attendance were less extreme than at Arthur's Pass, with no real peak in kea presence at any time of the day.

Manipulation of objects is thought to play a role in the learning process of young birds of several species (Ficken 1977). For kea, manipulative behaviours associated with exploration and exploitation of resources are considered part of the learning process of young kea as well as an adaptive strategy for the species (Kubat 1990, Diamond & Bond 1991). Grant (1993) suggested that feeding on anthropogenic foods, which are of high calorific value compared to the kea's natural foods, leaves kea with spare time to manipulate and play with any objects in their environment. This manipulative-play behaviour often results in damage to human property and may be detrimental to kea also.

In my study the proportion of manipulative-play activities was similar at the two study sites. Kea of all ages were observed at Craigieburn. Age-related differences in manipulative-play behaviours observed at this site, were consistent the idea that play

with objects is a way for young birds to learn skills in exploring and manipulating resources (Ficken 1977, Diamond & Bond 1991). However, kea observed at Arthur's Pass were mostly adult males, so it is unlikely that the manipulative behaviours observed there were part of an age-related learning process. At Arthur's Pass, kea manipulated human made objects significantly more often than at Craigieburn. Many of these objects (such as tents, rubbish bins and vehicles) yielded food only occasionally, but could still be considered potential food resources.

Results of my study suggest that the availability of anthropogenic foods has little influence on the frequency of manipulative activities, but does influence what these behaviours are directed toward. I did not establish whether it is anthropogenic foods alone, or a combination of these foods and types of equipment available to kea that influences the nature of the activities.

Many biological attributes of kea, including their inquisitive nature and ability to exploit both natural and anthropogenic resources (Diamond & Bond 1991, Grant 1993), are similar to those identified by Servheen (1985) for grizzly bears (*Ursus arctos horriblis*). Grizzly bears have become accustomed to anthropogenic foods at sites within their habitat that are frequented by people. The bears often destroy human equipment in their search for foods. It is possible that the concept of *behavioural corruptibility*, used by Servheen (1985) in relation to the behaviour of bears toward people and potential food sources, also applies to kea. Behavioural corruptibility implies that once kea become used to anthropogenic foods, they will continue to seek them out. Even if no foods are available, previous rewards have conditioned them to keep exploring for them. This could explain the manipulative behaviours directed to human objects by adult male kea at Arthur's Pass.

At Arthur's Pass some of the exploratory manipulative behaviours which yielded no

food rewards, were apparently converted into "play" behaviours. Such play behaviour was more common at Craigieburn than at Arthur's Pass. At Craigieburn manipulative-play activities were focussed on natural resources (e.g. stones, branches, twigs, pieces of bark, and lichens) and on interactions with other kea.

5.2 Hazards for kea at human occupied sites

Twenty-nine dead kea were found over a period of 38 months. All but two of these were recovered at Arthur's Pass in the area from Halpin's Creek Dump to Bottle Flat. For 52% of all kea recovered, the cause of death was directly related to, or a direct result of human activity. Nine of the 27 kea killed at Arthur's Pass were hit by cars. Other causes of death which could be identified were: ingestion of poisonous or indigestible substances (e.g. rubber), drowning in a water tank, and death following injury or illness.

At dawn and dusk, kea often prospected for food along the roadside at Arthur's Pass Village and near the Halpin's Creek Dump. On several occasions I observed kea nearly being hit by cars. At times kea appeared slow to move away from traffic. It is possible that these kea had become habituated to vehicles to the degree that they would not move until the last second. On some occasions kea were reluctant to move because they were feeding.

The relatively high proportion of adult males in the dead kea (36% of the aged and sexed kea) is a cause for concern. Male kea provide food for the female during incubation and chick rearing, for their chicks, and they continue to feed the fledglings for several months (Jackson, 1963, Wilson 1990a). In the Nelson area, kea chicks in a monitored nest died following the death of the adult male (G. Elliott pers. comm.).

Jackson (1969) reported kea dying of starvation and "scouring" at Arthur's Pass. He

assumed these deaths to be the result from lack of food in winter for kea at the bottom of their pecking order. Jackson (1969) described a variety of symptoms, including: bad coordination, stumbling, severe scouring, gross weight loss, muscular necrosis, green bilious droppings and haemolytic anaemia. Necrosis of the liver and muscles was found on dissection of some of these kea (Jackson 1969). I did not observe any sick kea during my study, but kea which were virtually unable to walk and others suffering from incoordination, had been seen in years prior to my study by DoC staff at both Arthur's Pass and Mt. Cook. I did observe abnormal green bilious kea droppings at Craigieburn in the winters of 1986, 1988 and 1989.

The symptoms described by Jackson (1969) are very much like those associated with lead poisoning in poultry and waterfowl (Elder 1954, Wisely & Miers 1956, Bagley & Locke 1967, Hungerford 1969). Gray (1972) reported the death of a captive kea, which was diagnosed with lead poisoning from lead-based paint on the animal's enclosure. It would be speculation to suggest that kea at Arthur's Pass did die from lead poisoning, and the other causes of death identified by Jackson (1969) should not be discounted. However, my observations suggest that lead poisoning is a potential risk for kea at human occupied sites. Manipulative activities directed towards buildings were observed at both study sites and kea commonly chewed on lead-head nails or lead flashing used in roofing. They also nibbled at paint on buildings, but it is unknown if those paints contained lead compounds.

Other inquisitive behaviours that were potentially hazardous included kea chewing on fibreglass insulation, removing and chewing insulation paper and plastic pipes, and tasting oil from a vehicle after biting through a hose (all at Craigieburn).

Kea banded at Arthur's Pass were consistently heavier than those banded at Craigieburn. It is possible that kea banded at Arthur's Pass were heavy as a result of the anthropogenic foods available to them, particularly as most Arthur's Pass kea were

banded at the Halpin's Creek Dump (2.2.1). If so, this could be cause for concern. Several wild bird and mammal species are known to scavenge on anthropogenic foods. Such scavenging can allow: faster maturation and earlier onset of breeding, bigger offspring, and/or high cholesterol levels and ill health (Graber, 1985; Burger & Gochfeld, 1990; Anon 1990). Big kea are not necessarily healthy kea, it is possible that the Arthur's Pass kea are obese which may interfere with their breeding success.

The inquisitive nature of kea, and the resulting ability to explore and exploit any resources in their environment, are probably beneficial to the species as a whole, but result in behaviours that put individuals that forage in villages and dumps at risk.

5.3 Kea-friendly habitat management

The aim of kea-friendly habitat management is to reduce the likelihood of conflicts between kea and people who live, work and recreate in kea habitat. Recommendations for kea-friendly habitat management based on this study were forwarded to DoC in March 1990 (Appendix I). A number of these suggestions were reflected in the Wild Kea Management Statement (Grant 1993).

The main problem areas identified in this study were: inadequate rubbish disposal; unsafe sites due to ill-maintained buildings; and people feeding kea. In many cases these problems were caused by people's thoughtlessness.

At Arthur's Pass, most rubbish bins were kea-proof, if used correctly, but were often left to overflow. This resulted in roadside litter regularly being available to kea. Rubbish was not always stored under cover. Solidified frying fat, discarded in the creek adjacent to the local tearooms, was a major attraction for kea. Solutions to these kind of problems are self evident.

DoC removed rubbish bins from certain road side picnic areas during the study, but

this did not result in less roadside rubbish. Rubbish was distributed widely through the vegetation adjacent to the road, and kea were found foraging in these places. Removal of rubbish bins needs to be supported with public eduction and information.

The Halpin's Creek Dump should be closed. Sites like this one provide unhealthy foods for kea, as well as many poisonous and unpalatable substances. Kea sustained injuries and were killed at the dump.

A building code for human occupied sites within kea habitat should include the following guidelines:

* All wiring and insulation materials should be covered and kea should not have access underneath buildings.
* Storm water and waste water drains should be covered
* The roofing systems used should not use lead head nails or lead flashing.
* Paints should be lead free.
* Fibreglass coating and/or tape can prevent kea damaging aerials.

Continued education of people using kea habitat is essential. During the study, DoC launched the "don't feed the kea campaign" in Canterbury. Pamphlets outlining the basic facts of kea ecology were made available to the public, and permanent signs intending to dissuade visitors from feeding kea were erected at Arthur's Pass and several skifields in the region. Throughout and subsequent to the study, people were observed feeding kea. People mostly fed kea to attract them for photographs or for closer inspection. Once people had tired of the kea they would try to scare them away on several occasions throwing objects or stones at them. Objects were also thrown at kea to encourage them to fly so that photographs could be taken of their underwing colours. This sort of provocative and aggressive behaviour was less common in the village, where people engaging in such behaviours could be seen by other people, in

particular DoC staff. These behaviours by people are harmful to kea, and could possibly be changed by further education. Results of a pilot survey to assess the effectiveness of the "don't feed the kea campaign" (Jarrett, Dennis & Bernard 1994) suggested that there is a growing awareness of the potential hazards (for kea) associated with kea feeding on anthropogenic foods.

Human behaviours are probably easier to influence than kea behaviours. As mentioned earlier (5.1), positively-conditioned kea will probably persist in exploring potential resources, even if the rewards are infrequent. Some measures, for example closure of the dump, are likely to be successful because they remove the attraction totally, whereas improved rubbish disposal in the Village or on the skifields will only lessen the attraction for kea. Manipulative behaviours by kea, directed toward tents and vehicles are likely to persist especially when such equipment is left unsupervised. Habitat management will have to be supported by education.

5.4 Future research

This study did not confirm the presumed link between anthropogenic foods followed by increased manipulative-play behaviours. A follow-up study, involving continuous observations of individual kea known to engage in manipulative behaviours which result in damage, may address this more successfully. However, the unpredictable nature of kea would make this a very challenging task.

To fully assess the impacts of anthropogenic foods on kea in the Arthur's Pass population, a study on the health and breeding success of these kea could be undertaken. Such a study would be complimentary to research carried out by Wilson (1990a,b) and Elliott (unpublished data). Necropsies of all kea found dead at human occupied sites would provide better information on the hazards these sites pose for kea. An attempt should be made to monitor any sick kea. Blood samples from live

kea and tissue samples from dead kea could be taken to test the hypothesis that lead poisoning is a potential hazard for kea.

Resighting data suggests that the kea at Arthur's Pass and Craigieburn are separate populations. It is not known if the total kea population is fragmented to the extent that there are genetically different sub populations. The use of modern electrophoretic or DNA techniques could be used to resolve this question.

Kea appear to have large overlapping home ranges. There is scope for studies to investigate the areas kea use, and how they use the features of their habitat. Movements of kea are still poorly understood, in particular dispersal of immatures.

The picture of seasonal attendance at the study sites which emerged from this study is not necessarily similar in other years. Repeat studies, or long term studies at the same sites are needed to establish a pattern of attendance.

5.5 Afterword

Nearly all New Zealand parrot species have the dubious distinction of being threatened or endangered. Kea are endemic, and a unique feature of the South Island alpine ecosystem, yet they were granted full protection only in 1986. Kea ecology is as yet little understood, and it is thought that the population may be in decline. Research, habitat management and education are integral parts of the conservation strategy for kea.

It is essential to provide and sustain a healthy and natural environment for kea, to ensure the continued existence of this species in the South Island mountains.

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APPENDIX I

Recommendations for kea-friendly habitat management

March 8th 1990

1. Arthur's Pass

Visitor Information

Any experiments involving relocation of or modification of rubbish bins should be accompanied by (kea-proof) signs advising park users to pack out what they pack in, with a brief explanation as to why this is desirable. Even a kea-proof rubbish bin is likely to invite mischievous behaviour of kea unless the public is informed on proper rubbish disposal. While the Halpin's Creek Dump is still open, referral of the public to the dump to dispose of rubbish should be avoided.

Referral of the public to the dump to view and/or photograph kea should be avoided at all times (this is presently happening in the village and residents need to be made aware that it is not in the best interest of kea to refer visitors to the dump).

Rubbish bin design

The bins currently used need very little modification to be kea-proof, but they will need a lot of information and collection management to avoid problems related to kea activity. (In light of the fact that Arthur's Pass is not the only locality on DoC estate where activity of kea around rubbish bin results in problems, design of bins could perhaps be shared by other DoC staff and be a South Island exercise rather than an Arthur's Pass project).

The lids on the wooden bins are adequate because they are heavy and cover the sides of the bin. Kea will have to sit on the lid to open it, and thus don't succeed. The lids of the plastic "waste management" bins are too light. Kea can open them when sitting on the bin or when bracing themselves against an adjacent structure. It appears that DoC staff have seen kea open these bins. If this can be verified, the use of the plastic bins should be

abandoned because of the danger of kea becoming trapped inside the bin.

Modification of the wooden bins should center on:

Preventing users from disposing of rubbish between the drum and the frame (a false lid would be an easy solution).

Preventing kea from getting underneath bins.

Maintenance / replacements of the lids when they are worn and no longer cover the sides of the bins.

Possibly preventing kea from climbing the wooden frames by using more solid pieces of wood (this is not necessary if no rubbish can get in between the drum and the frame, and may be undesirable because of reduced airflow).

Replacement of the bins at the Youth Hostel with wooden bins.

Rubbish collection

The person presently collecting rubbish in the village could be made aware of the fact that full or overflowing bins, and uncovered (or insufficiently covered) rubbish in the rubbish truck are best not left overnight (even if the vehicle is on private property).

During my study the same back yard where the vehicle with the rubbish was left overnight was made available to campers and on several occasions tents and campervans were present. The rubbish truck attracts kea and leaving it out should be regarded as highly undesirable.

Liaison

Liaison with district councils and private organisations operating on or adjacent to land administered by DoC should continue. The Halpin's Creek Dump is only one example; the dump at Otira also attracts kea. With regard to the dump, the preferred option would be to close it. In a few years when the present site is full, closure and alternatives for rubbish disposal will have to be considered anyhow, perhaps this date could be brought forward. If the dump remains open, recycling should be encouraged in the village.

Liaison with DoC staff both in Canterbury and in other conservancies, with regard to kea-friendly habitat management should be encouraged.

Restrictions on materials dumped

Large amounts of building materials and contents of (holiday) homes find their way into the Halpin's Creek Dump. There is a lot of traffic between Arthur's Pass and Christchurch, and it seems unlikely that those people who bring new materials to the Arthur's Pass can't take the old ones (back) to Christchurch, where there are better waste disposal facilities. A recycling scheme could be made operational in the Village, if the community was willing to support this.

Waste water drains

The waste water drains at the Outdoor Education Lodge could perhaps be covered as it is a favourite place for kea to fish for left overs.

2. Craigieburn

Amenity area

The amenity are at the skifield should be cleaned up, especially the area below the car park and behind LCAC lodge, and restored to a 'natural state'. All old tyres which are no longer functional should be removed.

Insulation of the water pipe at Koroheke should be fixed and be made kea-proof.

The toilets below LCAC lodge should be repaired (if still in use) or removed.

The sides of the buildings should be covered so kea cannot get underneath, where they damage insulation systems and water pipes.

Other skifields

The open dump at Cheeseman should be closed. Regular general cleanups on all fields, to minimise attractions for kea. All skifield operators be requested to take their rubbish (back) to Christchurch; this includes Temple basin, where there are currently provisions to use the Halpin's Creek Dump. Rubbish bins on the fields should be kea-proof and covered or inside, and no rubbish bins be left outside after the ski season has finished.